AN INVESTIGATION OF ENVIRONMENTAL KNOWLEDGE AND ATTITUDES INVOLVING THE DESIGN OF A TEST INSTRUMENT AND ITS USE WITH GRADE ELEVEN STUDENTS IN BRISBANE

SHORT TITLE: ENVIRONMENTAL KNOWLEDGE AND ATTITUDES IN BRISBANE SCHOOLS

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CONTENTS

ABSTRACT

An Investigation of Environmental Knowledge and Attitudes involving the Design of a Test Instrument and Its Use with Grade Eleven Students in Brisbane.

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The study details the environmental education opportunities in Brisbane at pre-school, primary and secondary levels and provides information about supporting agencies.

Literature relating to tests of environmental knowledge and attitudes is surveyed.

A full account is given of the steps taken in constructing preliminary tests using the findings of earlier researchers, but also approaching the task from first principles. Test validation was based on the assessments of a panel of experts who were provided with generally accepted definitions of environmental education. The preliminary tests were trialled, followed by item analysis. Items were retained, rejected or revised, some being used in the construction of a 60 item knowledge test. After further trials 30 knowledge items were selected for the final test. They relate to eight major categories of environmental concern and are evenly distributed between specific and applied knowledge. Ten attitude items were also included to assess optimism - pessimism regarding the future and willingness to surrender freedoms.

The test was administered to samples of approximately 100 Grade Eleven students from each of six schools, chosen to be representative of Brisbane high schools. Data was analysed using the computer program EVAL and the Statistical Package for the Social Sciences (SPSS) sub-programs REGRESSION, CROSS-TABS and ONEWAY.

For the total sample of 663 students the highest inter-correlations obtained were for knowledge and willingness to surrender freedoms (positive) and for optimism and willingness to surrender freedoms (negative). Students who knew more tended to be less optimistic. Males, in general, knew more, were more optimistic and less willing to surrender freedoms than females. Analysis of variance showed these sex differences to be significant. Significant differences were also found between schools on the three test variables and, for socio-economic level of school, on the variable knowledge. Students from the one school with a stated environmental philosophy scored significantly higher than the rest of students in knowledge and willingness to surrender freedoms, and lower in optimism. One school with an overt religious philosophy obtained a very low score on willingness to surrender freedoms, the difference from the rest being highly significant.

The investigation reports with a degree of optimism on the state of environmental education in Brisbane, but reveals some serious knowledge deficiencies. Among these were failure to appreciate that the earth's resources are limited and to understand evolutionary processes and the inter-relatedness of living things. The study points to the need for further quantitative evaluation.

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Environmental education is a new field of interest, and, because of this, there has been relatively little research into its effectiveness. This study seeks to provide such information for Brisbane.

In this chapter the place of environmental education in today's society is considered, the meanings of terms used are clarified, justification is provided for undertaking this project, and the scope of the thesis is outlined.

1.1 The Status of Environmental Education

The origins of environmental education are difficult to identify and its unique way of regarding the world is seldom seen in history. St. Francis of Assisi is one who merits consideration as a very early environmental educator. As White[1] explains, St. Francis taught the humility of mankind as a species, man's inter-relationships with other living things, and that man should be a brother in the animal kingdom rather than an exploiter of nature. Few others have shared his insights.

Worldwide concern with environmental education is a recent development which has only been generated in the years since Rachel Carson[2] alerted the world in the early nineteen sixties. She quoted Albert Schweitzer : "Man has lost the capacity to foresee and forestall. He will end by destroying the earth."

Further evidence of the dangers to mankind was provided by writers such as Ehrlich[3], Rattray Taylor[4], Hardin[5] and the Club of Rome[6]. There was even a Blueprint for Survival[7] endorsed by an impressive panel of British scientists. It is not surprising that education in matters relating to man's environment was accorded new status. Today it is widely recognized at a time when mankind looks towards an uncertain future.

Whether the world is doomed and we are committed to a rearguard action in the fact of extinction, or whether man's initiative will win

for him the golden era of peace and happiness, environmental educators are certain to be in the front line.

An optimistic factor is that in recent years there has been increased realization of the potential of environmental education to lead people to a fuller and richer life. This applies particularly as society adjusts to changes which bring more leisure opportunities, a greater percentage of the work force unemployed and a larger proportion of retired people in the population. Rillo's statement is a clear indication of its importance:

> "The major objective of environmental education is aimed at producing an individual who is motivated towards the rational use of the environment in order to develop the highest quality of life for all"[8].

In the years since 1970 environmental education has burgeoned, gaining recognition at every educational level. There is much to be done. O'Connor[9] describes it as "a great challenge to us as educators, because before environmental concern flowers in our society, we are the ones who have to implant the seed."

1.2 Definition of Terms

One of the problems in research is to establish terminology as a basis of communication. In the area of environmental education there has been considerable debate to delineate its limits and to establish meanings for the names involved. As terms such as environmental education, environmental knowledge and environmental attitudes are often used loosely, the following definitions are provided.

Environmental Education

The International Union for the Conservation of Nature and Natural Resources definition is a key statement:

> "Environmental education is the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among man, his culture and his biophysical surroundings. Environmental education also entails practice in decision-making and self-formation of a code of behaviour about issues concerning environmental quality."[10]

Environmental education embraces the three categories described by Lucas[11], education about the environment, education for the environment and education in the environment. The first is a cognitive approach, the second is the affective dimension which includes developing an interest in, and a concern for, environmental conservation. The third is the very effective way of enabling learning by practical experience. As Rillo contends, environmental education involves the "total environment of man-the biological, social, economic, cultural, ethical and aesthetic components."[12] Boyden and O'Neill[13] describe it as being pervasive, integrative, participatory and provocative, leading to a reassessment of values.

Other definitions make it clear that environmental education is not confined by subject boundaries and that it is holistic in nature, with an entity greater than its component parts. It should also be productive of action to improve and to conserve. Among these definitions is a lengthy statement from a Curriculum Development Centre proposal[14] and another used by Roth[15]. Rillo[16] considers that environmental education should begin at home with familiar surroundings and their problems, then move outwards in ever increasing concentric circles, while Roth and Helgeson[17] regard emphasis of the world-wide nature of problems as essential to its success. There are no firm limits to environmental education.

Environmental Knowledge

Environmental knowledge includes all the areas of the cognitive domain defined by Bloom[18] applied to environmental education as previously described. Because of the all-embracing nature of environmental education, environmental knowledge is equally wide in its scope.

Environmental Attitudes

Each individual, because of his life experiences, develops attitudes which determine how he behaves. Fishbein and Ajzen[19] discuss the meanings of "attitude" and, by extending their definitions to embrace the scope of environmental education, two definitions of environmental attitudes can be given:

1. Environmental attitudes are the degrees of feeling for or against anything living or non-living or any condition or circumstance.

For example, the word "kangaroos" may occasion a wide variety of internal reactions from different people, depending on their previous associations. These may or may not involve strong emotions.

2. Environmental attitudes are learned dispositions to respond in consistent ways to anything living or non-living or any condition or circumstance.

Questions relating to "the burning of rubbish" are likely to yield responses whose similarities accord with previous learning because they have been determined by it. Any attitude is unique to a particular person.

1.3 The Importance of the Study

The need for environmental education is now accepted by educational administrators, teachers and the general populace. A plethora of courses, conferences and seminars is testimony to this. Yet there is little to indicate how effective the various approaches have been and there are many unanswered questions. Do schools which make special provision for environmental education produce children who know more? Are their attitudes different from those of children in other schools? What is the relationship between environmental knowledge and environmental attitudes? Are there differences which are related to sex, socio-economic level or religious philosophy? Are the environmental education aims of the Queensland Education Department[20], which are listed in the next chapter, being realised in Brisbane schools? Are state schools different from independent schools in this regard? The study does not provide clear answers to these questions but it provides new information relating to each of them.

The specific aims of this investigation are:

(a) to construct a test of environmental knowledge and attitudes at Grade Eleven level

(b) to survey the opportunities for students to gain environmental knowledge and form attitudes in Brisbane

(c) to use the test to evaluate environmental knowledge and to determine certain environmental attitudes of Grade Eleven students in Brisbane

(d) to compare the test findings with those of earlier workers in Australia, the United States and Great Britain.

While it is certain that localised evaluation in this field has been carried out, the only major Australian statistical investigation having similar aims which has been reported is that of Eyers.[21] He concluded that the level of knowledge in Queensland (and the other Australian States and U.S.A.) was low, while attitudes were generally positive. However, no baseline data has previously been available for Brisbane. Now a thirty item knowledge test can be used, (see Appendix 2), together with test norms. This affords other investigators the opportunity to use the test to determine changes over a period of time. It will also enable comparisons within and between schools and between states.

A problem exists in trying to compare the level of environmental knowledge in schools with that of earlier years. The test enables this to be done for one school grade and it needs to be supplemented by a battery of similar tests at other grade levels. There was no formal introduction of environmental education in Brisbane schools. In the early seventies, say 1973, some teachers were sensitive to its nature and allowed it to permeate their teaching. Each year since there has been greater teacher acceptance of its ideals. It would be very interesting to compare the 1973 and 1978 environmental knowledge and attitudes. Though this can not be done, comparisons five years in the future will be possible. An adequate provision of test material at all school levels will be a most valuable adjunct to the other means of evaluation which are used today.

Chapter 2 records the results of an investigation of what is currently being done in environmental education in Brisbane. It also shows the opportunities available to teachers. By surveying the subject and associating it with the conditions which apply in a particular city at a particular time, the use of the test is set in perspective.

The third chapter is concerned with reported research into environmental knowledge and attitudes, most of which has been carried out in the United States. This leads into Chapter 4 where the methods used in the various stages of test construction are described. The procedures employed in test administration follow in the next chapter and the statistical techniques used are detailed. In Chapter 6 the results are analysed in several ways while the final chapter discusses the questions and hypotheses which have been raised, examining the evidence relating to them. It makes comparisons with other research, provides a summary and lists some consclusions reached.

The study raises new questions. It is to be hoped that it prompts similar investigations in other cities and Australian country areas. Environmental education in Brisbane, as described in the next chapter, should be compared with environmental education in other settings.

CHAPTER 2

ENVIRONMENTAL EDUCATION IN BRISBANE

2. ENVIRONMENTAL EDUCATION IN BRISBANE

It is reasonable to expect a degree of interest in environmental education in Brisbane. The city sprawls over a wide area, has large suburban allotments and, because of its climate, a tradition of outdoor living. It has a major river and easy access to beaches and the country. These are important natural advantages which need to be associated with good teaching and able education administration. The scope for this is outlined in the following pages.

It may be argued that there is no quantitative evidence of the quality of the teaching or of the implementation of sound administrative decisions. This study is an attempt to gain such information.

In the absence of research findings it is necessary to rely on first hand observations and subjective assessments. Personal involvement in education over some thirty years with an interest in developments at all levels has led to the opinions which follow. In general, the teachers of today are making better use of their opportunities than teachers in former years. It would be a serious indictment of the profession if they were not.

There have been a number of improvements leading to a more favourable climate in schools. In-service education is available, class sizes have been reduced, teacher aides are employed and schools are better equipped. One of the most significant improvements has been in teacher education. Increased expenditure in this area has provided better buildings, better facilities, and, most importantly, better staffing. With three year courses replacing the former two year training period, teacher educators have offered a much more thorough preparation for teaching. It is from universities and

colleges that much of the environmental education initiative stems. A result is that beginning teachers at pre-school, primary and secondary levels are helped towards an awareness of their roles as environmental educators. This is developed, not only through pre-service practical experiences like the educational use of field studies centres, but through the consideration of related philosophical issues as well.

Older teachers have not enjoyed these benefits, and, although there is considerable inertia in the system, it is being overcome. Up-grading courses and seminars, accompanied by increased freedom to innovate, are assisting to provide an orientation towards environmental education.

Along with the family and the community, the school is a prime agency of environmental education. It has been traditional to advise young teachers that every teacher in English is a teacher of English. By the way he speaks and writes a teacher exerts a marked influence on his charges. A similar situation exists regarding environmental education. The classroom, the school ground and the staff of the school have profound effects on children's knowledge, attitudes and behaviour in their environment, whether or not there is overt teaching in this area. As a result the experiences of individual children are likely to differ widely.

The sections which follow survey the levels of schooling and the supporting agencies which extend the influence of the classroom.

2.1 Pre-School and Primary Education

Children who are afforded the opportunity to attend pre-schools are provided with experiences which lead to an appreciation of the interest and beauty of the world around them and a knowledge of their

dependence on other people and other things. This extends into primary schooling where each class teacher has unique opportunities to extend children's awareness and direct their learning. For example, certain teachers at Sandgate State School have made use of the neighbouring lagoon with its diversity of bird life, while children at Cribb Island State School have a nature trail which has certainly helped them to an understanding of the importance of mangroves and tidal mud flats. Even in the most urbanised areas there are possibilities which a committed teacher will turn to good account.

While environmental education can be a focus or a by-product of activities in any primary subject, certain areas of science and social studies offer the greatest scope for it.

Since 1966 most science teaching in primary schools has been based on The Syllabus or Course of Instruction in Primary Schools[22] which was published in that year. However, the subject science has often been avoided by teachers because of their self-perceived inadequacy, and an Education Department survey[23] showed that one of the most commonly used teaching strategies was to show the primary science T.V. programmes. Discussion with teachers revealed that often this was the only formal science for their classes, although there was a considerable amount of incidental science and environmental education in a typical week. The situation is improving. Teachers entering the service have been provided with a good preparation for teaching science. Science advisory teachers who encourage experimentation with curricula and methods are also playing an important part. The Primary Science Syllabus Committee is engaged in a programme of school based curriculum development which will enable schools to choose the best approach for them from a considerable variety of alternatives, all with a sizeable component in the area of environmental

education. While there is evidence of experiment and change in some schools, others are reluctant to move. The survey previously referred to showed that most teachers did not want a new syllabus, which may be taken as a tribute to those who developed the existing one in the early sixties. Certainly they showed foresight in using conservation as one of the five major subdivisions. The 1966 syllabus has "Man's Environment" as its central theme.

In Social Studies the 1970 *Syllabus in School Studies for Primary Schools*[24] is used in all but a small percentage of schools. It too has an extensive environmental education content, as the following themes indicate.

Grade 1 : The individual in a changing environment.

Grade 2 : Groups in an expanding community.

Grade 3 : People in differing environments.

Grade 4 : How our way of life developed.

Grade 5 : Meeting the needs of society.

Grade 6 : The development of various societies.

Grade 7 : Understanding the present in order to plan for the future.

The introduction of this syllabus was assisted by a programme of in-service education to orient teachers to the new approach needed. In order to gauge whether the hoped for changes have occurred, a number of educators were approached. Their consensus was that there has been considerable improvement compared with teaching prior to 1970, although this improvement has not been universal.

A widespread advocacy of correlation and subject integration in primary teaching has extended the possibilities of science and social studies in making children environmentally aware. Every subject can contribute towards this goal and the opportunities for a primary school class teacher are unlimited.

2.2 Secondary Education

In secondary education there have been numerous curriculum introductions in recent years, many of which are referred to in this chapter[25]. The Radford Report of 1970 recommended the abolition of the Junior and Senior external examinations and the establishment of a Board of Secondary School Studies. It aimed to release schools from narrow examination-oriented teaching and has given them considerable freedom.

Syllabus approval became the responsibility of the Board of Secondary School Studies, and a system of moderation in schools enabled the monitoring of standards.

On perusing the available syllabuses approved by the Board it is apparent that teachers have been accorded freedom of choice to a high degree and that opportunities for continuing environmental education exist in a wide variety of subjects. Apart from the "Board" subjects of the Board of Secondary School Studies which are discussed below, there are "School" subjects which are merely noted by the Board of Secondary School Studies. No school, state or independent, has reported an interdisciplinary subject "Environmental Studies", though "Environmental Science" and "Science for Living" are listed. This is consistent with the thinking of most experts in the field of environmental education.

As would be expected, Biological Science and Earth Science make major contributions in the first three secondary years. There is a subject Environmental Physics and the interdisciplinary study Science Applied to Social and Industrial Problems[26]. Discussion with school inspectors reveals that it is common for high school science to be taught from an environmental perspective (often with too much time devoted to biology compared with the other sciences).

Because of the nature of the subject Geography, almost all units or sections listed in the syllabuses contribute to environmental education[27]. History has less potential, but in Grade 8 topics such as immigration and rural problems are dealt with, while the syllabus for Grades 9-10 includes a major unit entitled Issues Facing Australian Society[28]. Social Science for Grades 8-10[29] provides most extensive opportunities for environmental education. The same claim can be made for Citizenship Education[30] and Social Studies[31]. Grades 8-10 Home Economics[32] has environmental components, in particular the areas of Human Development and Relationships and Housing and Design. The syllabus in Art[33] for these grades has "Environment and Man" as its theme while Health and Physical Education[34], Agricultural Science[35] and Agricultural Subjects[36] have significant environmental education emphasis.

Whatever subject choices are made by students, their school experience to the end of their Grade 10 year should have brought, in a variety of ways and on a number of occasions, an appreciation of inter-relationships involving man and his world. During the next two years of schooling more opportunities arise.

In the sciences the same list of topics is available for treatment at greater depth and with different approaches while Geography has particular scope, especially the unit Man and the Environment. The successful trialling of this new development in 1973 was reported by Simson[37]. Since then it has been widely used. Modern History[38], Economics[39], Art[40], Health and Physical Education[41], Agriculture and Animal Production[42], Home Management[43], Home Economics[44], all provide further possibilities for environmental education.

If teachers are prepared to grasp the opportunities, the educational structures of curricula provide all that is needed for secondary students to gain a vital environmental awareness.

This study investigates the environmental knowledge and attitudes of students early in their Grade 11 year so that it is the environmental education opportunities to Grade 10 level which are its major concern.

A detailed analysis of how the various syllabus requirements are met in all subjects and all schools is beyond the scope of this study. An enormous range of text books and other curricular materials are used, with a comparable range in the extent to which they involve environmental education.

2.3 Agencies Providing Support for Environmental Education

One pleasing feature of Queensland education is the increase in first-hand experience outdoor education. No syllabus, text book or other aid to learning is completely effective without a teacher's commitment to making it succeed. Similarly, the provision of outdoor facilities is not enough to guarantee worthwhile practical experience in environmental education. However, Brisbane schools are making good

use of the available field study centres. The Maroon Outdoor Education Centre is booked almost to capacity for a year ahead. The properties at Jacob's Well, Stanley River and Bunyaville, which are easily accessible to Brisbane schools each have throughputs of about 2000 children per year. Koomburra is being developed to educate teachers in field study techniques while the Fortitude Valley centre provides for urban studies. Here children investigate the Valley as a place to live and a place to work.

Teachers who make use of these facilities are helped greatly towards the attainment of the Education Department aims of environmental education. These are:

1. Develop in pupils an understanding of how man is using and misusing his resources.

2. Introduce the pupil to his local cultural and natural environments past and present, and help him to realise that he is part of them.

3. Provide an opportunity for pupils to develop field skills through environmental problem solving.

4. Provide an opportunity for pupils to develop social and physical skills through adventure and challenge.

5. Assist pupils to develop and review attitudes, values and sensitivity conducive to enjoyment of, concern for and wise use of the environment.

6. Assist pupils to develop a realisation that the solution of environmental problems often lies in group and political action[45].

Implementation of these aims involves the Co-ordinating Committee on Environmental Education, the Camp Development Committee, the Physical Education Branch, the Agricultural Project Club Branch and the Curriculum Branch. Of particular interest is the Environmental Advisory Team[46] which helps teachers to investigate their school environment so that they

can conduct field activities. The team consists of four specialists with a variety of expertise. They make a comprehensive report for each school according to the specific requirements of teachers. Among the items of equipment provided for them are station wagons and a caravan. The caravan has a field studies laboratory which can be used as a photographic dark-room and an area appointed for teachers to examine materials and engage in discussion.

The Pilot Environmental Education Project of the Curriculum Branch of the Education Department prepares teachers' guides and aids to practical study as well as reports on each of the field study centres as they are brought into use.

A novel approach which has been investigated is the use of a barge in Moreton Bay and the Brisbane River as a mobile teaching base. For many years the Physical Education Branch of the Education Department has provided for school camps, notably the Camp School at Tallebudgera. There are several additional camp sites where environmental education is provided for Brisbane children.

Most independent schools conduct camps and excursions and several have developed properties. Among these are St. Peter's terrestrial study area, Ironbark[47], Brisbane Grammar School's property which is at the Moogerah Dam site and Peel Island camp centre belonging to the Church of England Grammar School. Various churches also conduct camps with an environmental emphasis.

A Scout Association facility at Eprapah is used in scouting and by other organisations while at the Mt Coot-tha Botanic Gardens an Education Officer provides practical environmental teaching for as much of the school spectrum as possible. Twenty-

seven hectares of structured plant communities have been developed for study[48]. Queensland Museum Education Officers also make worthwhile contributions.

National Parks and Wild Life Services has organised Junior Rangers and promotes environmental education via literature. It has also organised weekend workshops to make teachers and others more aware of the services offered. Schools have been invited to co-operate with the Service in a study of animals killed on roads. The Schools Commission's Innovations Projects[49] have been instrumental in extending environmental interest. For example, the National Directory of Innovations Projects for 1976 lists eight grants within the category of environmental studies in Brisbane. School science contests and the Science Contest of the Queensland Science Teachers' Association attract a large proportion of environmental studies entries. Another important input comes from wild-life conservation programmes on television. There is no shortage of opportunities for environmental education in Brisbane.

While the aims and opportunities are impressive, they do not ensure that every child in every school has the experiences and the teaching that others enjoy. Not every home makes positive contributions to environmental education. Some teachers have accepted few of their responsibilities, some schools have less to offer than others. Considerations such as these have led a number of educators to advocate prescribed courses in environmental education instead of the generally accepted approach which involves all subjects.

There is a need to assess the effectiveness of current educational practice, to discover what knowledge has been gained, what attitudes have been developed and how knowledge and attitudes are inter-related. The next chapter deals with reported research into testing in these areas.

CHAPTER 3

THE TESTING OF ENVIRONMENTAL KNOWLEDGE AND ATTITUDES

3. THE TESTING OF ENVIRONMENTAL KNOWLEDGE AND ATTITUDES

Because it is only in recent years that environmental education has been given widespread recognition, evaluation research in this field has not been extensive. Nevertheless, since 1961 there have been a number of reported studies which have relevance to this work.

An investigation concerned solely with environmental knowledge was made by Rentsch[50]. He developed an instrument to measure "the level of understanding of minimal spaceship earth concepts an environmentally literate citizenry should possess" and used it to assess the environmental literacy of teacher education students for each concept.

Others have researched attitudes. Hoover and Schutz[51] investigated the conservation attitudes of university students, Steiner and Barnhart[52] and Steiner[53] used high school seniors as their subjects while Bowman's work[54] was with college students. Ray's research[55] was in a different area and involved the use of a commercial polling organisation to discover the attitudes of the general public to certain environmental questions.

The exploration of knowledge, attitudes and their inter-relationships has been reported by Cohen and Hollingsworth[56] using high school students and Hounshell and Liggett[57] using younger children. More recently Fleetwood and Hounshell[58] made an important contribution in this area. Other significant knowledge and attitude research is that of Perkes[59], Eyers[60] and Richmond[61]. All of these studies were carried out in the United States except those of Eyers and Ray (Australia) and Richmond (England).

3.1 Studies of Environmental Attitudes

Knapp[62] in 1972 concluded that "research on attitudes about environmental issues has been limited and inconclusive". A similar claim could be made today despite the importance of the following studies.

Hoover and Schutz[63] were early workers in the field. Using a factor analysis technique, they developed a measure of conservation attitudes. Its use indicated the presence of basic value systems which determine behaviour with respect to conservation. This was a noteworthy study with implications for teaching. One conclusion was that, in order to make students "conservation oriented", it is necessary to strive to alter or maintain values and attitudes rather than to emphasise factual knowledge.

George[64] showed that outdoor activities such as conservation clubs and nature camps have significant positive effects on conservation attitudes.

Steiner and Barnhart[65] used factor analysis in constructing their Inventory of Societal Issues which can be used to assess environmental attitudes. The factors they isolated were:

1. Regard for human life with specific referents abortion, euthanasia and drug use.
2. Disillusionment and pessimism regarding the implications and outcomes of man's scientific and technological involvement with nature.
3. The need to co-operate with nature rather than subjugate it. Specific referents include conservation and preservation of the environment and natural resources.
4. Concern for the problem of increased population and the implications or consequences of this increase and its control.

5. The need to take personal responsibility for current societal problems.

6. Optimistic belief in the ability and desirability of science and technology to solve societal problems and to deal with environmental deficiencies.

7. The desire to have and allow individual freedom.

This research was seen as most valuable for the present investigation, and the factors, particularly 2, 6 and 7, were important determinants of the attitude questions which were incorporated in the test developed for use in Brisbane schools.

The Inventory of Societal Issues was used successfully by Steiner[66] to determine the attitudes of a representative sample of Oregon high school seniors. He compared the responses of students in relation to the amount of science they had taken, their school environment and their sex. There were significant differences involving four of the factor scales and the total inventory. However, the attitudes of seniors who had taken a maximum of science were not significantly different from others on four of the factor scales, including two concerned with scientific and technological developments. Steiner draws attention to this indication that science teaching should be linked with related societal issues.

Bowman[67] constructed and validated a test to assess college student attitudes to environmental issues. Using pre-test and post-test methods she showed that student attitudes could be changed as a result of an introductory environmental management course.

The Australian Environmentalism Scale constructed by Ray[68] and his Australian Political Conservatism Scale were administered to a random stratified sample of people in the Sydney area, together with tests of extraversion and neuroticism. Ray's environmentalism scale consists of twenty statements on environmental issues with a choice of five responses for each item. It is a measure of environmental concern. His other scale is similarly constructed and measures political conservatism or radicalism. Ray found that environmentalists tended to be politically radical, were more likely to be female and were slightly less neurotic than others tested.

3.2 Studies Concerned with Both Environmental Knowledge and Attitudes

A comprehensive study of this type was made by Perkes[69] in 1973. He developed three forms of an inventory consisting of items dealing with knowledge of specific facts, general concepts and attitudes to the environment. It was used with tenth and twelfth grade students in eleven American states. Males obtained significantly better results than females on items requiring knowledge of facts but not on environmental concept items. Twelfth grade students scored significantly higher than tenth grade students on environmental concept items but not on those requiring knowledge of facts. Attitude differences were slight. Interesting differences were found in what students considered to be the major environmental problem. These differences were related to where they lived - the size of their community and their state.

Hounshell and Liggett[70] used the Environmental Knowledge and Opinion Survey with Grade Six children in North Carolina. There were no significant differences between the sexes in knowledge scores but girls showed a more positive attitude towards the environment. An extremely high correlation between

knowledge and positive environmental attitudes was obtained. There was no significant difference between the attitude scores of urban and rural children. There was a difference between their knowledge scores, urban children scoring significantly higher.

Cohen and Hollingsworth[71] investigated the relationship between environmental knowledge and attitudes. A questionnaire with thirty-five environmental information questions and thirty-five attitude questions was used with high school students. The results for a low environmental knowledge group and a high environmental knowledge group were compared. There were differences in attitudes between the two groups and the group with the more information was more willing to express an attitude.

To test the environmental education of Grade 10 students in Australia, Eyers[72] used twenty-nine knowledge items, a source of information item and ten belief items. This was in 1974 when, for the first time, many Australians were becoming aware of the need for environmental concern. Only 4.2% of children involved claimed that special courses were the major source of their knowledge about the environment. Students who claimed reading and media as their major source were more successful than others. In knowledge Eyers found differences between states but only small differences between regions. There was little difference between types of school (Government, Catholic or Independent). Males were slightly better than females in the knowledge items. On the belief items differences between school types were greater than for the knowledge questions. On some items significant differences between the sexes were obtained. Again the media and reading group scored better than other groups based on source of information.

A total belief score was computed, revealing significant differences depending on type of school, region and source of information.

Fleetwood and Hounshell[73] prepared an Environmental Science Test to measure individual understanding of environmental education concepts. They also constructed an Environmental Attitude Inventory to assess feelings towards the environment and environmental protection in North Carolina. Both instruments were reported to discriminate adequately between individuals, to possess content validity to a high degree and to be reliable measures of the aims of environmental education.

Richmond[74] tested fifth year secondary students in England, most being fifteen or sixteen years of age. The questions involving knowledge of facts produced poor results, but those requiring understanding of environmental concepts were better answered. In other questions the students showed considerable agreement with the validating panel in expressing positive attitudes to the environment. There was evidence corresponding to findings of Perkes[75] that environmental attitudes which concern personal sacrifice are not always consistent with expressed general attitudes.

Factual knowledge scores showed significant differences related to sex, school type, school sex (whether "all boy" or other), school size and region. The differences obtained for school sex and school size could be occasioned by the success of males compared with females and the poor results of students in secondary modern schools. The same variables were associated with significant differences between scores on conceptual understanding questions. For the belief items only school type and school sex provided significant differences in total scores.

Richmond obtained a correlation of 0.48 between conceptual knowledge and attitude scores, 0.44 between factual and conceptual knowledge and 0.38 between factual knowledge and attitude. The results point to the importance of information and understanding in developing positive environmental attitudes

The work of Perkes[76] in the United States, Eyers[77] in Australia and Richmond[78] in England affords interesting comparisons between the three countries. In each country boys were superior to girls in knowledge questions. Perkes suggested that this might be explained in terms of the different science backgrounds of boys compared with girls. Eyers postulated a lower motivation in girls, brought about by their view of the role of females in society. Richmond accepted that both these ideas have merit. There certainly has been educational discrimination against girls in each country. Richmond points out that educational and social changes should tend to eliminate the discrepancies. There was cause for concern that knowledge scores were so low in each country.

3.3 Studies of Particular Relevance to this Investigation

Apart from Steiner and Barnhart's[79] work which has already been described as an important reference, there are four investigations of those previously detailed which are closely related to this study.

The first is Fleetwood and Hounshell's[80] research which included the construction of their Environmental Science Test and Environmental Science Inventory. These were designed for biology students involved in environmental education programmes. A strong feature of the test design used by Fleetwood and Hounshell is the classification of items in terms of Bloom's[88]

taxonomy so that items categorised as Knowledge, Comprehension, Application, and Analysis are included in each of the classifications Eco-systems, Natural Resources, Pollution and Environmental Decision Making. Similarly, the inventory uses the categories Receiving, Responding and Valuing in association with The Study of the Environment, Conservation of Natural Resources, Pollution and Politics and Policy Making for a Quality Environment.

The other studies most closely related are those of Perkes[82], Eyers[83], and Richmond[84]. Although they apply to the United States, Australia and England respectively, they were all associated with the Ohio State University and Professor Robert W. Howe, the Director of the Educational Resources Information Center, Science Mathematics and Environmental Education Information Analysis Center (ERIC/SMEAC). Much of the important American research in environmental education has originated in this university with its ready access to information.

The test designed by Eyers was selected as one of four tests for use in the preliminary testing programme. This was done so that statistical comparisons could be made and to enable an assessment of test difficulty. Richmond's system of item classification was adopted. He was able to gain from the experience of Perkes and Eyers and consulted with experts in England as well as America. The classification he devised (see 4.2 Construction and Use of Test 5) was most appropriate for this study. Most of the other researchers had some effect on the test design which follows, though credit is difficult to apportion.

CHAPTER 4

TEST DESIGN

4. TEST DESIGN

The previous chapter described a number of ways to assess environmental knowledge and attitudes. Each of these has its merits and each was devised to suit particular circumstances and to attain specific ends. Although some features of earlier research are embodied in the current work, it represents a substantially new approach. By returning to first principles instead of using items from some of the tests described, new ground was broken. Three stages of test construction and item analysis were involved - with the preliminary tests, Test 5 and the Final Test.

4.1 Preparation of the Preliminary Tests

A variety of sources was used to establish the content of the tests.

Twelve definitions and statements dealing with environmental education were listed. From them important words and ideas were extracted. To these were added related key words from text-books, periodicals and curricula together with information from other researchers.

Roth[85], in an early survey, had examined 111 concepts, reducing them to twelve major conceptual areas, while Archbald and Gundlach[86] used Roth's work to identify fifteen key environmental education words - environment, resources, man, plants, water, populations, public, political, life, culture, social, values, economic, energy, technology. These were included in the pool. Further input came from Jinks[87] who found five concepts to be fundamental to the explanation and interpretation of environmental phenomena, viz: patterns, balance, evolution, causality and origins. Fleetwood and

Hounshell[88] used the resources of the Science, Mathematics and Environmental Education Information Analysis Centre (SMEAC), text-books, periodicals, curriculum guides and publications from environmental education conferences. They identified four dimensions of environmental education - ecosystems, natural resources, pollution and environmental decision making. These findings also provided sources for questions. Other sources were Stapp's[89] valuable instructional model and the list of concepts provided by Swan and Stapp[90].

Using all of these references as resources and stimuli, a pool of multiple choice items with four alternatives was created. The items written were considered to have construct validity because of the procedures followed. A selection of 120 items was made and these were grouped in three forty item tests involving knowledge and attitudes.

It was considered advisable to submit the tests to a panel of approximately ten environmental educators for validation and comments. Nine of those approached agreed to co-operate and were used. They comprised an Education Department Administrator, a curriculum research officer, two lecturers, the Deputy Principal of the Maroon Outdoor Education Centre, an adult education teacher and three high school teachers. All had the required interest and experience in the areas to be investigated.

Members of the panel were provided with the definitions from the International Union for the Conservation of Nature and Natural Resources[91] and the draft of the United States Education Act[92]. They were asked to indicate whether, in terms of these definitions, particular items were contributing to the measurement of environmental education. Those items regarded as not valid by more than two of the panel were rejected.

The three tests, designated Test 1, Test 2 and Test 3, and that of Eyers[93], designated Test 4, were administered to one hundred Grade Eleven students at a state high school. Optical computer cards were used with the programme described in Chapter 5 (5.4) to analyse the results. For knowledge items the scores were generally higher for the new tests than for that of Eyers. An index of difficulty, the proportion of testees choosing the correct response, was obtained for each item. The discrimination index was also obtained for each item. This is a measure between 0 and 1 of how well scores on the item contribute to scores on the whole test. The range for this statistic is from - 1.00 to 1.00, the best items having high positive values. A negative value indicates that good students, as measured by the whole test, tend to get the item wrong while poor students tend to get it right. Many items were discarded because their discrimination index was less than 0.30. However, the results in this regard compared well with those for items from Eyers' test.

The reliability of tests is also determined by computer as internal consistency or split-half reliability. Scores on a random selection of half the items are correlated with scores on the other half. Because two of the tests had attitude items for which there was no correct answer, the reliability could only be determined for one test, but again the value obtained compared favourably with that for Eyers' test.

A number of distractors had to be replaced because they were chosen by fewer than ten percent of the testees. Others had stems or distractors which required rewriting in the light of comments by the validating panel.

4.2 Construction and Use of Test 5

As a result of the procedures followed there were 46 items available to be part of Test 5, a sixty-item test of environmental knowledge. It remained to be seen whether these sampled the various areas of environmental knowledge sufficiently well and whether an extra 14 items provided enough scope to remedy any bias.

At this stage reference was made to the work of Richmond[94]. After examining current literature and consulting with American and English educators and researchers in this field, Richmond identified eight categories of environmental concern.

1. Pollution
2. Population
3. Natural Resources
4. Land Use
5. Energy
6. Environmental Health/Safety
7. Ecological Relationships
8. Social/Political/Economic Influences.

Richmond does not provide weightings for these categories. He used a panel of experts to validate his test.

> "The final instrument was examined by the panel and it was agreed that the nature of the specific items, and the proportion of items devoted to each area, were appropriate to the rationale and objectives of the study"[55]

A tally of his items gave the following totals for the respective categories 1 - 8: 19, 13, 19, 12, 12, 10, 9, 10. These allocations appear to be arbitrary and the situation is complicated by an overlap in some questions so that they could have been classified differently.

Examining the items for inclusion in Test 5 showed that the validation procedures which were used had led to a greater emphasis on Ecological Relationships and Social/Political/Economic Influences than Richmond's but that all categories were sampled. Cognisance was taken of the need to include questions classified according to Bloom's[96] taxonomy as other than knowledge of specifics. To this end it was decided to draw up a matrix listing each of Richmond's categories on one axis with knowledge of Specifics and Knowledge Applied on the other. Extra items were constructed to ensure that each cell of the matrix was represented. The test had between 6 and 10 items in each of Richmond's categories of environmental concern as shown in Table 1. (See Appendix 1. Test 5).

TABLE 1

DISTRIBUTION OF TEST 5 ITEMS

Category	Knowledge of Specifics	Knowledge Applied
	Item Number	Item Number
Pollution	3,35,43,49,53,60	29,33
Population	30,55,56,57	24,25,54
Natural Resources	26,34,59	4,13,18,42
Land Use	8,10,50,51	7,52
Energy	1,5,45,47	19,23,58
Environmental Health and Safety	36	6,9,20,44
Ecological Relationships	48	2,11,12,14,22,28, 39,40,41
Social/Political/ Economic Influences	16,32,38	15,17,21,27,31,37 46

Test 5 was administered to 98 Grade Eleven students at a Brisbane independent school and the results were analysed by computer. The mean score was 39.8 and standard deviation 8.5 The internal consistency of the test was exceptionally high, 0.89, (see Chapter 5, 5.4), the range of difficulty of the items was satisfactory and almost all items discriminated well between high-scoring and low-scoring students (mean index of discrimination = 0.38). Statistics which relate to this testing are shown in Table 2.

TABLE 2

RESULTS OF TESTING WITH TEST 5

Item No	Difficulty Index	Discrimination Index	Item No	Difficulty Index	Discrimination Index
1	0.71	0.34	31	0.62	0.47
2	0.84	0.39	32	0.88	0.45
3	0.81	0.35	33	0.22	0.25
4	0.30	0.44	34	0.63	0.43
5	0.82	0.30	35	0.81	0.44
6	0.32	0.37	36	0.90	0.38
7	0.66	0.41	37	0.85	0.45
8	0.87	0.19	38	0.24	0.23
9	0.41	0.45	39	0.77	0.43
10	0.54	0.34	40	0.41	0.50
11	0.48	0.37	41	0.72	0.51
12	0.30	0.51	42	0.32	0.35
13	0.63	0.50	43	0.36	0.41
14	0.63	0.31	44	0.39	0.44
15	0.55	0.30	45	0.80	0.39
16	0.70	0.39	46	0.87	0.36
17	0.80	0.27	47	0.67	0.43
18	0.50	0.45	48	0.61	0.31
19	0.74	0.32	49	0.28	0.40
20	0.36	0.29	50	0.67	0.45
21	0.78	0.35	51	0.59	0.50
22	0.51	0.36	52	0.48	0.37
23	0.57	0.42	53	0.16	0.12
24	0.67	0.33	54	0.06	0.11
25	0.11	0.36	55	0.73	0.50
26	0.74	0.43	56	0.64	0.49
27	0.68	0.40	57	0.73	0.42
28	0.45	0.39	58	0.80	0.48
29	0.66	0.52	59	0.42	0.22
30	0.70	0.39	60	0.51	0.31

4.3 Selection of Knowledge Items for the Final Test

(See Appendix 2 for the Final Test - Environmental Education Test). Selecting the 30 items which discriminated best gave a total of 14 classified as testing Knowledge of Specifics and 16 concerned with Knowledge Applied. There were totals of from 3 to 5 for each of the categories of environmental knowledge, at least one item in each cell of the matrix and a mean difficulty index of 0.66 and mean discrimination index of 0.44.

Because the final testing was to be carried out with students in March of their Grade Eleven year and this testing has been done with Grade Elevens in November, it was deemed advisable to aim for a lower mean index of difficulty. Also, certain items were preferred on grounds which were partly subjective. For example, those involving negatives were rejected.

The 30 items chosen for the final test have a mean difficulty index of 0.61 and mean index of discrimination of 0.39. There is at least one item in each cell of the matrix. Fourteen are classified Knowledge of Specifics and sixteen as Knowledge Applied, as shown in Table 3.

TABLE 3

DISTRIBUTION OF FINAL TEST ITEMS

Category	Knowledge of Specifics	Knowledge Applied
Pollution	3,25,30	17
Population	15,27,28	12
Natural Resources	18	10,13
Land Use	6,26	4
Energy	1,23	11,29
Environmental Health & Safety	19	5,22
Ecological Relationships	24	2,7,20,21
Social/Political and Economic Influences	8	9,14,16

Many of the items could be classified differently. For example, No. 8 could have been listed in the category Population and there is an overlap between categories such as Pollution and Environmental Health/Safety. However, the methods used in item construction, revision, and selection should ensure that the final test is a valid measure of environmental knowledge.

4.4 Construction of Attitude Items

It was planned that this study should investigate the relationship between knowledge and attitudes. However, a comprehensive survey of stated attitudes could not be made if the test was restricted to forty items, with ten allocated to attitudes. After discussion and reading, particularly of Steiner and Barnhart's[97] work, it was decided to devote five questions to each of two areas. These are the optimism - pessimism continuum and willingness to surrender freedoms. They relate to most of the Steiner and Barnhart factors listed in Chapter 3 and were considered to be worth exploring. It seemed likely that there would be a relationship between the environmental knowledge of students and their responses to questions concerned with these attitudes. Knowing more of world problems was predicted to create pessimism and willingness to surrender freedoms.

To add variety some items were framed inversely. For example, Item 31 has the statement "Mankind will become extinct within a few hundred years" while Item 33, also testing optimism - pessimism, states "As each year passes Australia becomes a better place to live in."

For the attitude items five alternatives were used - strongly agree, agree, uncertain, disagree, strongly disagree. The test involves several aspects of optimism and pessimism and deals with a variety of freedoms, for example to pollute, to have children and to use cars.

While attitude items had been included in the preliminary tests, these were discarded and the ten items finally used were not subjected to testing. They were discussed with colleagues and revised before inclusion.

After following the procedures described, the forty-item test was available for use in schools.

CHAPTER 5

USE OF THE TEST INSTRUMENT

5. USE OF THE TEST INSTRUMENT

There are several requirements for effective testing. Firstly, it is necessary to have specific aims and these are conveniently expressed in terms of the investigation of hypotheses. There have to be children to test which necessitates sampling of schools. The procedures to be followed in the schools need to be specified and, after testing, the way to deal with results has to be planned. This chapter provides detailed information concerning each of these areas.

5.1 Hypotheses

In Chapter 2, a detailed account of the opportunities for environmental education is given. Many of the important features it embraces are not readily assessed. However, testing can be used to provide some information as to whether students are profiting from their school experiences. There is also a need to discover the extent to which variables affect the learning process. In Chapter 1 a number of questions are raised. The test was used in an attempt to answer them and to provide baseline data concerning environmental education in Brisbane.

The following null hypotheses were selected for testing:

1. There is no significant relationship between the environmental knowledge of Brisbane Grade Eleven students and

   (a) sex
   (b) school
   (c) type of school (co-educational or single sex)
   (d) type of school (with or without an overt religious philosophy)
   (e) type of school (state or independent)
   (f) socio-economic level of school
   (g) type of school (with or without a stated environmental philosophy).

2. There is no significant relationship between the expressed optimism-pessimism attitude to the future, of Brisbane Grade Eleven students and

   (a) environmental knowledge
   (b) sex
   (c) school
   (d) type of school (co-educational or single sex)
   (e) type of school (with or without an overt religious philosophy)
   (f) type of school (state or independent)
   (g) socio-economic level of school
   (h) type of school (with or without a stated environmental philosophy)

3. There is no significant relationship between the expressed attitude to individual freedom of Brisbane Grade Eleven students and

   (a) expressed optimism-pessimism attitude to the future
   (b) environmental knowledge
   (c) sex
   (d) school
   (e) type of school (co-educational or single sex)
   (f) type of school (with or without an overt religious philosophy)
   (g) type of school (state or independent)
   (h) socio-economic level of school
   (i) type of school (with or without a stated environmental philosophy)

5.2 Choice of Schools

Practical limitations precluded the use of a random stratified sample of Grade Eleven students in Brisbane and it was decided that six schools, representative of the major categories, should be chosen. A state high school for each of the three socio-economic levels was required and two independent schools. Another school was included because of its environmental education programme.

In selecting the high schools, reference was made to *Brisbane at the Census; 1971, A Social Atlas*[98], which provided information concerning the socio-economic characteristics of Brisbane suburbs.

One of the features of Brisbane is its lack of homogeneous areas so that clusters of low cost dwellings are found in suburbs generally regarded as upper class. Also, a particular statistical division may have a number of areas within it, representing the complete range of socio-economic levels. Because of this, it is usual for Brisbane schools to include children from each class of society.

Another contributing factor is public transport which may result in children attending a school situated in a very different social setting from that of their home locality.

In order to assess the socio-economic level of a school, a scale developed by Broom, Jones and Zubryzcki[99] can be used. The results obtained give a rating for the school within the range 0-6. Three state high schools were chosen to represent upper, middle and lower socio-economic levels. Their ratings are shown in Table 4. In each case the ratings had been determined by the school administrations. It was unfortunate that the difference between the ratings for schools 2 and 3 was not greater, but the schools were chosen before these statistics were available. Application was made to the Queensland Education Department for permission to administer the test in these schools.

It was decided that a Grammar school and a Catholic school should be included in the testing programme. School 0, a girls' school, was selected, so that, to retain approximately equal numbers of males and females in the study, it was necessary to choose a Catholic boys' school. The school which agreed to participate was designated School 5. School 4, which has a stated environmental philosophy, is a co-educational independent school. Each of the three non-state schools was rated in the upper socio-economic level by

consensus of a number of educators. The six schools gave a sample which is fairly typical of the state and independent schools in Brisbane.

TABLE 4

SCHOOLS USED IN TESTING

School Number	Type of School	Socio-Economic Level	Socio-Economic Rating
0	Grammar (girls only)	high	-
1	State	lower	2.26
2	State	middle	3.71
3	State	high	4.00
4	Independent (environmental philosophy)	high	-
5	Catholic (boys only)	high	-

5.3 Administration of the Test

Visits were made to each of the schools, requesting that a representative sample of at least 100 Grade Eleven students be made available for testing early in March, 1978. This was an inconvenience to schools, particularly as an hour was required to allow for distribution of materials, introduction, explanation and doing the test. It was not feasible to arrange a random sample from each school so that the extent to which the sample was representative depended on the assessment of the school administration. Particular classes were provided by the schools, only one allowing all Grade Eleven students to undertake the test.

The testing was supervised personally in all schools between 1 March and 16 March. Each child was provided with a pencil, a numbered test paper and two optical computer cards. A code number for each school was entered on the computer cards. To ensure motivation the students were advised that their results on the thirty knowledge items would be made available to the principals, deputy principals and teachers of the subjects covered by the test, and that their test papers would be returned to them. It appeared that in every case the students were strongly motivated and found the test interesting. There was a negligible number of answer omissions from the 663 individuals in the sample.

5.4 Statistical Techniques

As the testing in each school was completed, the cards were analysed using the programme EVAL[100]. As described in Chapter 4 (4.1) this computer programme proved to be very useful for item analysis in constructing the tests. EVAL lists the range of scores, score frequencies, cumulative percentage frequencies, and a measure of the reliability (internal consistency) of the test. The split-half reliability used is obtained from the formula

$$r = \frac{2r_1}{1 + r_1}$$

where r_1 is the correlation between scores on the two halves of the test. Values of r between 0.80 and 1.00 are sought in test construction. A rank ordering of the results of testees is also provided.

From the computer print-out result lists were prepared for each school, giving the scores for all students on the thirty knowledge items and the school mean. Schools were supplied with ten copies of the test paper, ten result sheets and ten answer sheets which also showed the percentage of students getting each item correct. All the cards from the six schools were them submitted to the programme EVAL to obtain the test norms for the knowledge items and statistical information concerning them - the percentages of students choosing each response, the index of difficulty and discrimination index.

An analysis of the factors influencing knowledge scores was undertaken using the Statistical Package for the Social Sciences[101] (SPSS) Version 7.01 as implemented on the Prentice Computer Centre PDP 10 at the University of Queensland.

The original variables were sex, school, ten attitude items of which five relate to optimism and five to willingness to surrender freedoms, and knowledge score. Additional variables were created. The variable "optimism" was computed from responses to items 31, 33, 35, 37 and 39, (A=1, B=2, C=3, D=4, E=5), except that items 33, 37 and 39 had to be reverse scaled. Similarly, the variable "Willingness to surrender freedoms" was computed from items 32, 34, 36, 38 and 40, with 32, 36 and 38 requiring reverse scaling.

Other categorical variables were created using the variable "school." For "school, single sex or co-educational," the results of schools 0 and 5 were compared with the rest. For the variable "school, religious philosophy," Schools 4 and 5 were involved while for "school, state or independent," the groups were 1, 2, 3 and 0, 4, 5 respectively. "Socio-economic level of school" involved the three independent schools and School 3 as upper, School 2 was

classed as middle and School 1 as lower. For "School, environmental philosophy," School 4 was compared with the rest of the schools.

Correlation Analysis

The SPSS sub-programme REGRESSION[102] was used to obtain correlations between variables.

The technique of multiple regression combines the predictor variables (independent variables) to produce an estimate of the dependent variables. The model is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + e$$

where Y is the value of the dependent variable,

$\beta_0, \beta_1, \beta_2 \ldots\ldots \beta_n$ are parameters in the model,

$X_1, X_2, X_3 \ldots\ldots\ldots X_n$ are the values of the n independent variables and e is a random error term.

The method of least squares is used with the sample information to get estimates of $\beta_o, \beta_1, \beta_2, \ldots \beta_n$. Let these estimates be $b_o, b_1, b_2, \ldots\ldots b_n$ respectively and $\hat{Y}$ be the estimate of Y based on these values for b.

Therefore, $\hat{Y} = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n$ is the model used for predicting values of the dependent variable Y.

The degree of relationship achieved is denoted by R, the multiple regression coefficient. R is a measure of the overall fit of the data to the model. As is the case for the simple correlation coefficient, r, this index ranges from - 1.000 to 1.000.

Squaring R gives R^2, the coefficient of determination, which is the proportion of the variation in Y explained by the regression.

$$R^2 = \frac{SSR(b_n, b_{n-1}, \ldots b_1/b_0}{TSS}$$

where SSR is the sum of squares due to the regression and TSS is the total sum of squares.

If $\hat{Y} = Y$, the prediction is perfect, then $R^2 = 1$.

If $\hat{Y} = \bar{Y}$, then $R^2 = 0$.

R^2 measures the usefulness of $b_1, b_2, \ldots b_n$.

The importance of each predictor is represented by the magnitude of its beta weight. These values are in the range -1.000 to 1.000. The beta weight for a variable represents the unique contribution of that variable to prediction of the criterion, i.e., its value as a predictor independent of all other predictors.

The print-out of REGRESSION also provides values for r, simple inter-variable correlation coefficients.

To further demonstrate the relationships between knowledge, optimism and willingness to surrender freedoms, the distributions of these variables were trichotomised and cross-tabulations were carried out using the SPSS sub-programme, CROSSTABS[103]. This programme uses variables in pairs, providing a plot of one against the other. The distributions of each variable are divided into low, medium and high scores and the percentages in each cell of a nine cell matrix are printed out. By adding the percentages in the diagonal cells a measure of the inter-variable correlation is obtained.

Three multiple regression analyses were undertaken. An attempt was made to predict knowledge scores using the eight predictor variables, sex, optimism, willingness to surrender freedoms, school (single sex or co-educational), school (religious philosophy), school (state or independent), socio-economic level of school and school (environmental philosophy). Similar analyses were made using optimism and willingness to surrender freedoms as dependent variables.

Analysis of Variance

Analysis of variance estimates are made of the population variance, one derived from statistics between groups, the other from statistics within a group. The size of the ratio of these two variances, the F-ratio, shows whether a group is significantly different from the population as a whole. The SPSS sub-programme ONEWAY[104] determines F-ratios and indicates their level of significance, that is the probability of such a difference occurring by chance. It was decided to report differences at the level of 0.05 or less as significant.

ONEWAY was used 39 times to determine the significance of differences between scores on knowledge, optimism and willingness to surrender freedoms, using all the stated variables.

In the light of information obtained as the investigation proceeded, the opportunity was taken to create additional variables and make further comparisons. Analyses were made using scores for Non-Catholic independent schools (0 and 4), boys from Schools 4, girls from School 4 and the whole sample from School 0 on the three test variables.

The computer programme used the Scheffe Procedure[105] to determine homogeneous sub-sets from scores for knowledge, optimism and willingness to surrender freedoms. This was done for the variables school and socio-economic level of school.

CHAPTER 6

ANALYSIS OF RESULTS

6. ANALYSIS OF RESULTS

The results of the testing are presented under several headings. After dealing with individual items, various groupings of items are used and the statistical techniques described in Chapter 5 are employed. Because the test covers such wide areas of knowledge as well as the two attitude domains, the responses lend themselves to extensive analysis. The distributions of scores on the major variables, knowledge, optimism and willingness to surrender freedoms, are recorded and illustrated, and inter-variable relations explored.

6.1 Responses to Items

For the knowledge items (1-30) students were instructed to select the best alternative. The correct response is marked with an asterisk and the figures on the left indicate the percentages of students choosing particular responses. The bracketed figure is the discrimination index for the item.

1. Most electricity in Australia is produced in

2		A.	power-houses which burn gas	
1		B.	power-houses which burn oil	(0.40)
79	*	C.	power-houses which burn coal	
16		D.	hydro-electric projects	

2. For photosynthesis to occur in plants it is necessary to have

3		A.	organic material in the soil	
0		B.	super-phosphate applied regularly	(0.20)
94	*	C.	an atmosphere which allows sunlight to pass through	
0		D.	the presence of trace elements including boron	

3. Ozone is

7		A.	the gas in most pressure packs	
3		B.	a chemical spray which kills insects	(0.38)
15		C.	the outer area of an ecosystem	
73	*	D.	a gas in the upper atmosphere	

4. Which of the following makes for good soil?

8 A. a pH value below 4
74 * B. the presence of nitrogen - fixing bacteria (0.29)
5 C. an increased concentration of sodium chloride
11 D. provision for regular leaching

5. A balanced vegetarian diet can be recommended for human beings because it

40 A. ensures that a maximum of protein is available
21 * B. allows for a short energy-efficient food chain
4 C. provides more calories than any other diet (0.27)
33 D. lacks any carbohydrate or fat content

6. Within a forested area

9 A. the earth is shielded from all solar radiation
56 * B. carbon dioxide is converted to oxygen (0.32)
12 C. few ecological interactions occur
21 D. the soil is always strongly acidic

7. If there is a large increase in the food supply for an animal species at a time when there are few of its predators the most likely result of this is

5 A. no change in the population of the species but a sudden increase in the number of predators
7 B. the numbers of predators and their prey becoming approximately equal (0.43)
7 C. a further decrease in predator numbers
78 * D. an increase in the population of the species followed by an increase in the predator population

8. Which of the following is true for Australia?

67 * A. large numbers of people have moved from the country to the cities
15 B. most of the population consists of migrants from overseas
14 C. the ten year average population increase is 7 percent per annum (0.35)
2 D. there are plans for new cities to be bigger than Brisbane by 1990

9. Which is the best description of a typical Australian dwelling?

7 A. two rooms, privately owned
1. B. twelve or more rooms, air-conditioned (0.17)
0 C. one bedroom, high rise building
89 * D. two or three bedrooms, large allotment

10. The earth is said to be like a spaceship. This is because it is

9 A. travelling through space at the speed of light
35 * B. unable to increase its available amounts of air and water
36 C. moving in a direction which cannot change (0.41)
19 D. equal in weight to the volume of gas it displaces

11. With which one of the following do you agree?

51 * A. when electricity is made from coal some energy is lost in heating the environment
26 B. there is a negligible energy use in constructing hydro-electricity schemes compared with their annual energy production
15 C. all the energy in plants is retained by animals which eat them (0.27)
6 D. where life exists (in the biosphere) each time energy is transferred the total energy increases

12. Which of the following countries suffers least from overpopulation?

41 A. Mexico
38 B. Holland (0.20)
14 * C. France
4 D. Japan

13. Which one of the following lacks major developed oil fields?

5 A. the North Sea
14 B. Venezuela (0.38)
4 C. Iran
75 * D. Central Australia

14. As a result of many families using two cars

2 A. there has been a slight decrease in the number of bicycles sold in recent years
7 B. the number of Australians employed making cars has doubled since 1975 (0.26)
14 C. all new houses have double garages or car-ports
75 * D. more oil and steel has to be produced

15. Which of the following is true?

9 A. in most underdeveloped countries the population has remained about the same in recent years

73 * B. the total world population increases greatly each year (0.32)
8 C. the United States has the world's greatest rate of population increase
8 D. Australia's population is expected to double by 1990

16. Which is the most likely long term result of increased migration and intermarriage between people of different races?

14 A. the percentage of childless marriages would increase
69 * B. most people would have darker skin than typical Europeans of today (0.42)
6 C. the human race would decline in intelligence and physical strength
8 D. people with fair hair and black skin would become very common

17. With which of the following statements do you agree?

8 A. the sun's energy will be used up within a thousand years
25 * B. the activities of people are helping to heat the earth and its atmosphere (0.31)
21 C. plants and trees use up all the carbon dioxide produced by man
44 D. ash from volcanoes is never likely to affect the world's temperatures

18. With which of the following statements do you agree?

9 A. Farming the sea will provide enough food for the world within five years
9 B. problems of diet for people in underdeveloped countries can be solved by providing more carbohydrate food
65 * C. the world's most important food plants are rice, wheat and corn (0.35)
14 D. within five years a cheap process for obtaining fresh water from salt water will solve food production problems in dry areas of the world

19. A necessary step to be taken in Australia is to

0 A. expand the whaling industry
3 B. increase the phosphates in our rivers
94 * C. improve methods of waste disposal (0.22)
0 D. encourage the use of insecticides

20. If hugh numbers of a particular species are killed in one year

11 A. it will be extinct within ten years
81 B. populations of other species will be affected
0 C. disease will attack the remaining individuals (0.42)
6 D. the next generation will be born with better survival abilities

21. What is the likely effect of several years of good seasons with heavy rainfall in dry parts of Australia?

44 * A. increases in the population of birds
25 B. the evolution of many new eucalyptus species (0.46)
18 C. an overall decline in marsupial numbers through drownings
11 D. most fish in inland streams washed out to sea

22. If a radioactive element has a half-life period of 40 days the amount left after 160 days from a 16 gram sample would be

19 A. 8 grams
38 B. 4 grams (0.39)
15 C. 2 grams
25 * D. 1 gram

23. A disadvantage of electric cars is that

68 * A. their batteries often need recharging or replacing
8 B. passengers are in danger of electrocution
0 C. they are too fast (0.38)
22 D. they need to be made of non-conducting material

24. The decomposition of substances so that elements are recycled is best performed by certain

4 A. herbivores
6 B. carnivores
64 * C. bacteria (0.30)
24 D. nitrogen-fixing organisms

25. Which of the following has an important function when dissolved in river water and is present in very small amounts in badly polluted streams?

27 A. carbon monoxide
37 * B. oxygen
9 C. hydrogen (0.41)
25 D. boron

26. In Queensland the land use which involves the greatest area at this time is

5 A. national parks
59 * B. grazing
26 C. farming (0.43)
8 D. forestry operations

27. An approximation to the population of Sydney is

3 A. 20,000
13 B. 200,000
79 * C. 2,000,000 (0.32)
3 D. 20,000,000

28. An approximation to the population of Australia is

83 * A. 14 million
7 B. 140 million
3 C. 1,400 million (0.37)
5 D. 14,000 million

29. An advantage provided by a hot water system which depends completely on solar power is

7 A. guaranteed hot water in all weather conditions
1 B. low installation cost
87 * C. low running cost (0.40)
3 D. hotter water than electric systems produce

30. It is likely that the waste from nuclear power stations

5 A. can be safely stored indefinitely in steel tanks
6 B. is used in industry as a source of energy
84 * C. will contribute to radioactive pollution (0.35)
3 D. can do no harm after 50 years

31. Mankind will become extinct within a few hundred years.

4	A.	strongly agree
11	B.	agree
33	C.	uncertain
38	D.	disagree
13	E.	strongly disagree

32. Citizens should be prepared to pay more for goods so that firms are able to pay for pollution control.

5	A.	strongly agree
25	B.	agree
12	C.	uncertain
42	D.	disagree
16.	E.	strongly disagree

33. As each year passes Australia becomes a better place to live in.

4	A.	strongly agree
28	B.	agree
22	C.	uncertain
38	D.	disagree
8	E.	strongly disagree

34. People should always have the right to decide the number of children they have.

46	A.	strongly agree
32	B.	agree
5	C.	uncertain
13	D.	disagree
3	E.	strongly disagree

35. Radioactive waste and other pollution will eventually make the world uninhabitable.

25	A.	strongly agree
38	B.	agree
22	C.	uncertain
12	D.	disagree
2	E.	strongly disagree

36. There should be stronger laws to control littering and conservation and they should be rigidly enforced.

60	A.	strongly agree
34	B.	agree
3	C.	uncertain
1	D.	disagree
1	E.	strongly disagree

37. By the year 2050 world problems such as war and poverty will be solved.

2	A.	strongly agree
8	B.	agree
32	C.	uncertain
38	D.	disagree
19	E.	strongly disagree

38. In future years it may be necessary for individuals to give up some of their freedom for the general welfare of mankind.

7	A.	strongly agree
43	B.	agree
31	C.	uncertain
14	D.	disagree
4	E.	strongly disagree

39. In Australia the conservation measures which are being taken by governments are adequate.

2	A.	strongly agree
10	B.	agree
14	C.	uncertain
48	D.	disagree
25	E.	strongly disagree

40. In Australia people should be able to use cars as much as they wish even if they cause over-crowding on the roads and serious pollution.

4	A.	strongly agree
9	B.	agree
13	C.	uncertain
40	D.	disagree
33	E.	strongly disagree

6.2 Analysis of Responses

There were 12 knowledge questions on which 75% or more of subjects were correct. Each category except Land Use is represented. However, examination of the items classified in the Land Use category shows that only one of three is clearly within this area. Because of this it is not possible to claim Land Use as an area neglected in schools. Little can be generalised from these 12 questions. Similarly, the four questions on which 25% or fewer testees were correct do not provide enough evidence to make generalisations about major areas of weakness.

The items are listed in categories for further analysis.

Pollution (Items 3, 27, 25, 30)

While almost three-quarters of the students knew what ozone is, only one in four realised that the activities of mankind are heating the earth and its atmosphere. Surprisingly few were aware of the importance of dissolved oxygen in streams but a high percentage responded correctly to the question on waste from nuclear power stations.

A school inspector complained that students are being subjected to so much teaching about pollution in various subjects that they are bored by it. This indicates a need for closer liaison within teaching staffs. The results on these questions highlight the need for careful planning to ensure that the important principles are taught thoroughly.

Population (Items 12, 15, 27, 28)

Knowledge of North America is not as extensive as might be expected as forty-one percent of students thought Mexico suffered less from over-population than Japan, Holland or France. The difference between over-population and population density needs to be understood. The majority were aware of the increasing world population and made correct choices concerning the approximate populations of Sydney and Australia.

Natural Resources (Items 10, 13, 18)

Three quarters of testees knew that Central Australia has no major developed oil fields, fewer correctly chose that rice, wheat and corn are the world's most important food plants, while barely a third knew why the earth is like a spaceship.

The concept of spaceship earth is fundamental to environmental understanding. Teachers and students would profit from reading Hardin's *"Exploring New Ethics for Survival, The Voyage of the Spaceship Beagle"*[106]. This analogy is extremely useful and could be the basis for a comprehensive unit of work at primary or secondary level. Rentsch[107] goes further and defines all the requirements for what he calls "environmental literacy" in terms of "spaceship earth concepts". If students have not internalised this concept it indicates a failure to integrate their factual knowledge. There are consequent responsibilities for teachers.

A sizeable number considered that desalination of water will solve food production problems in dry areas of the world within five years.

Land Use (Items 4, 6, 28)

There was a surprising lack of knowledge of land use in Queensland as shown by Item 26, and the question on forests was not well done. Essentially, this means that photosynthesis is not understood. It is hard to imagine a more serious problem than this in the areas tested. Students scored better on the question relating to soil.

Energy (Items 1, 11, 23, 29)

The fact that solar hot water systems are cheap to run was well known.

Students also knew that most Australian power houses were coal fired. Half of them did not know that energy was lost in making electricity from coal. The question on electric cars revealed that thirty percent of students consider that the disadvantage of electric cars is either the need to make them

of insulating material or the danger of electrocuting passengers. There is some confirmation here of the neglect of other sciences in favour of biology which is mentioned in Chapter 2. Teaching physics with an environmental perspective could make it more acceptable to those who find it the most difficult part of science courses.

Environmental Health and Safety (Items 5, 19, 22)

A major deficiency in this area relates to dietary knowledge and is a matter of concern. Grade Eleven students should know that a vegetarian diet does not ensure a maximum of protein and does not lack carbohydrate or fat. The question on waste proved ridiculously easy but relatively few students understood half-life of radioactive elements, despite the debate over radiation dangers.

Ecological Relationships (Items 2, 7, 20, 21, 24)

Almost all students knew that photosynthesis depends on sunlight but fewer than two thirds knew the role of bacteria as decomposers. A more thorough treatment of this area of biology, emphasising the ecological relationships, appears to be necessary. Items 7, 20 and 21 discriminated particularly well between high and low scorers on the test as a whole. The relationship between food supply and population was understood as shown by Items 7 and 20, but this knowledge was not well applied in Item 21. There are implications for teaching when a quarter of students think that many new eucalyptus species could evolve in several years. This is a very serious deficiency because an understanding of evolutionary processes is essential to knowledge of the inter-relationships of all living things, including man.

Rentsch[108] regards it as a necessity for his "environmentally literate citizenry" and, while it is not listed as part of some of the best environmental education programmes, it is certainly implicit in their statements.

Social/Political/Economic Influences (Items 8, 9, 14, 16)

Scoring on these items was considerably above the average with students being able to select the description of a typical Australian dwelling and knowing that two-car families create a need for increased oil and steel production. Almost a third of those tested did not know about the population drift to the cities. Item 16 proved to be a very good item, providing further evidence of a need for teaching in the areas of evolution and genetics.

Additional Information Obtained from Distractors Chosen In Knowledge Items

In a multiple-choice test where there is no penalty for wrong answers, students who do not know the right answer will select the most plausible distractor, or guess. The testees in each school were strongly motivated and did not appear to make random choices as they were doing the test. Some significant knowledge deficiencies are illustrated by the distractors they selected.

The numbered statements which follow are from distractors which were chosen by twenty-five per cent or more of testees and which have not already been discussed.

1. The earth is said to be like a spaceship because it is moving in a direction which cannot change. (Item 10)

Here the obvious inferences are that students have done little physics when they are unaware that a space-ship changes its direction and little astronomy if they do not realise that the earth must change its direction in moving round the sun.

2. There is a negligible energy use in constructing hydro-electricity schemes compared with their annual energy production. (Item 11)

Few teachers would be aware of the enormous energy cost in the manufacture of materials and the construction of dams. This raises doubts as to the viability of some proposed hydro-electricity schemes. Choice of this distractor was predicted.

3. Holland suffers least from over-population (compared with Mexico, France and Japan). (Item 12)

This choice indicates a lack of knowledge of the geography of Holland and France and the distribution of population in Europe. Population studies should have a high priority at this time.

4. Ash from volcanoes is never likely to affect the world's temperatures. (Item 17)

Had the magnitude of the eruption of Krakatoa been appreciated, this mistake would not have been made. The subject is of great interest and importance so that its apparent neglect is hard to explain.

5. Carbon monoxide has an important function when dissolved in river water and is present in very small amounts in badly polluted streams. (Item 25)

6. As for the previous statement, "boron" replacing "carbon dioxide". (Item 25)

Item 25 was the type of question which would lead students who were ignorant of the importance of dissolved oxygen to guess. It is interesting that boron was chosen almost as often as carbon monoxide.

7. In Queensland the land use which involves the greatest area at this time is farming. (Item 26)

It is most surprising that this mistake could be made by so large a percentage of students. Many city children obviously lack knowledge of the rest of Queensland. The excellent television documentaries about the state, which should have dispelled this ignorance, were probably ignored in favour of light entertainment.

In the foregoing analyses comments have been made about individual items, drawing attention to some apparent deficiencies in knowledge. Following further scrutiny of individual items it was decided to classify them broadly as Biological Science, Physical Science and Social Science to see whether this yielded information concerning strengths or weaknesses in knowledge. Table 5 shows the results.

TABLE 5

BROAD CLASSIFICATION OF KNOWLEDGE ITEMS

Biological Science		Physical Science		Social Science	
Item No.	% Correct	Item No.	% Correct	Item No.	% Correct
2	94	1	79	8	67
4	74	3	73	9	89
5	21	10	35	12	14
6	56	11	51	13	75
7	78	17	25	14	75
16	69	22	25	15	73
20	81	23	68	18	65
21	44	29	87	19	94
24	64	30	84	26	59
25	37			27	79
				28	83
Mean % Correct	61.8	Mean % Correct	58.6	Mean % Correct	70.3

It can not be assumed that the questions in Biological Science, Physical Science and Social Science are of equal difficulty. Nevertheless, the difference in favour of Social Science was expected. Some of the Social Science questions could be regarded as general knowledge, though their subject matter would also be included in certain of the courses described in Chapter 2. Social Science knowledge is often reinforced by television, especially current affairs programmes. There is much less science, particularly physical science, on television. It could be that a heavier commitment in school science is needed to ensure balanced environmental education.

The Attitude Items

Items 31-40 are concerned with beliefs and attitudes. Students were told there was no "correct" answers for these questions. They were asked to indicate their opinions. The odd numbered items relate to optimism - pessimism, the others are to assess willingness to surrender freedoms.

An interesting feature of this part of the test was the extent to which students were prepared to express definite opinions rather than to opt for the response "uncertain."

Optimism (Items 31, 33, 35, 37, 39)

A majority of students did not expect mankind to become extinct within a few hundred years but more considered that radioactive waste and other pollution would eventually make the world uninhabitable. There was little optimism concerning the problems of war and poverty and more disagreed than agreed that Australia becomes a better place to live in as each year passes. A large majority regarded Australia's conservation measures as inadequate.

Willingness to Surrender Freedoms (Items 32, 34, 36, 38, 40)

Most students were not prepared to pay more to enable pollution control by firms, nor were they prepared to forego the right to decide the number of their children. There was a remarkably strong vote for rigidly enforced laws to control littering and conservation. Half the sample saw that in future years some freedoms may have to be forfeited for the general welfare of mankind, while, in line with this, only a small proportion saw the continued use of cars as an unalienable right.

6.3 Results and Distributions of Scores on Knowledge and Attitude Questions

Scores on the knowledge items were widely distributed with a range from 4 to 29 and standard deviation of 4.3 No student was correct on every item. A value of 0.73 was obtained for the reliability of the thirty item knowledge test. This value was satisfactory, but much less than the figure obtained with Test 5. The overall mean score was 19.3 out of a total of 30. This result reflects the care taken to ensure that the test was of reasonable difficulty, rather than an absolute standard of environmental knowledge. However, it provides a norm for future testing.

Table 6 and the histogram of scores on knowledge items show the way scores were distributed.

TABLE 6

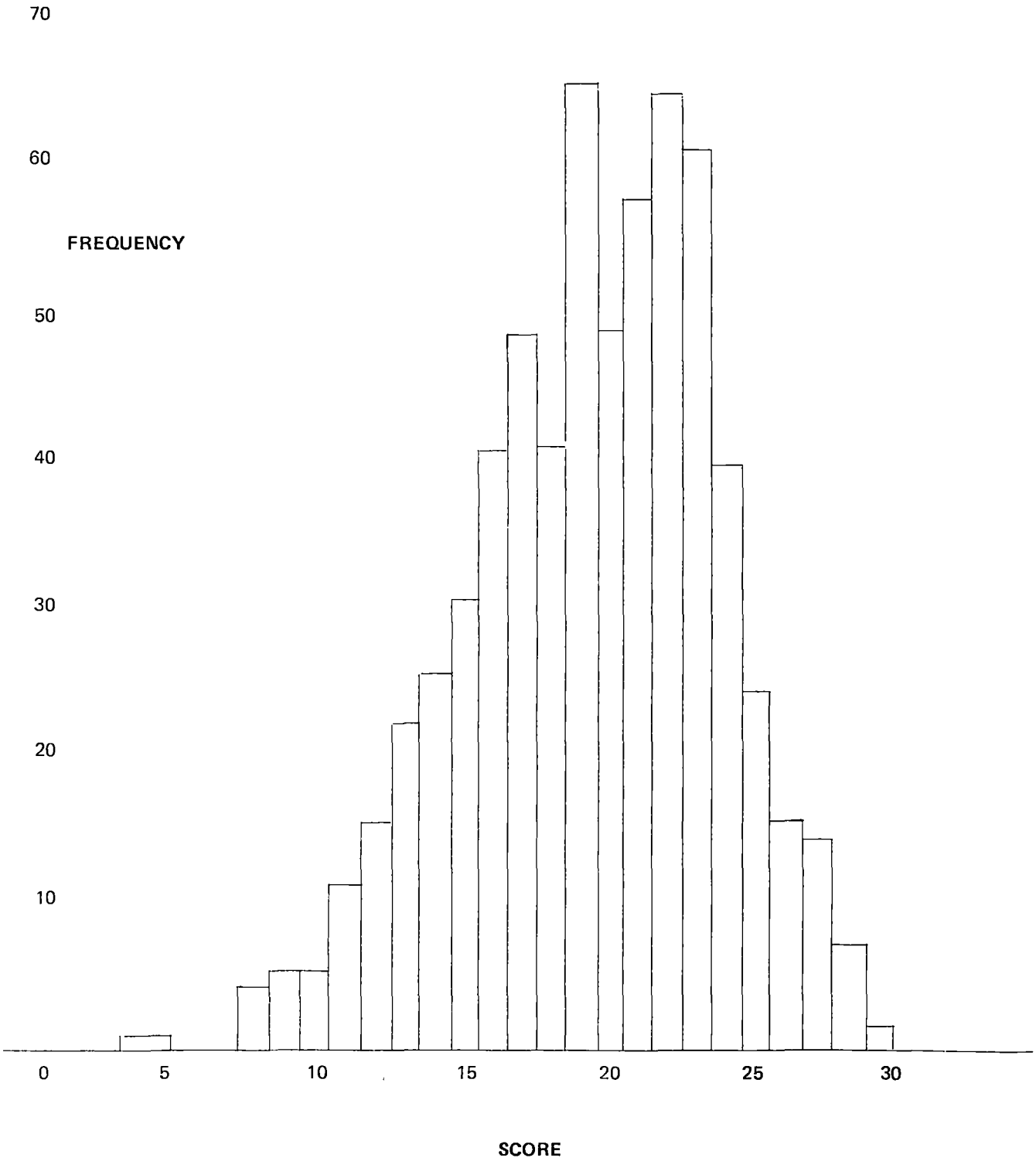
FREQUENCY DISTRIBUTION FOR SCORES ON 30 KNOWLEDGE ITEMS

SCORE	FREQUENCY	CUMULATIVE PERCENT
4	1	0
5	1	0
6	0	0
7	0	0
8	5	1
9	6	1
10	6	2
11	12	4
12	16	7
13	23	10
14	26	14
15	31	19
16	41	25
17	49	32
18	41	38
19	66	48
20	49	56
21	58	65
22	65	74
23	61	84
24	40	90
25	25	93
26	16	96
27	15	98
28	8	99
29	2	100

MEAN SCORE = 19.3 NO. OF STUDENTS = 663 STANDARD DEVIATION = 4.3

HISTOGRAM OF SCORES

ON 30 KNOWLEDGE ITEMS



To score the attitude items, 31-40, A=1, B=2, C=3, D=4, E=5, except that, because of their wording, items 32, 33, 36, 37, 38 and 39 had to be reverse scaled A=5, B=4, C=3, D=2, E=1.

The possible score for optimism ranges from zero (extreme pessimism) to 25. The same range applies to the variable willingness to surrender freedoms.

The testing gave scores for optimism ranging from 4 to 23 with a mean of 13.0 and standard deviation of 2.7. For willingness to surrender freedoms the range was 3 to 25, the mean 16.3 and the standard deviation 2.9.

Table 7 and Table 8 and the histograms which follow show the distributions of scores.

TABLE 7

FREQUENCY DISTRIBUTION FOR OPTIMISM SCORES

SCORE	FREQUENCY	CUMULATIVE PERCENTAGE
4	1	0.2
6	3	0.6
7	9	2.0
8	22	5.3
9	32	10.1
10	42	16.5
11	78	28.2
12	95	42.6
13	83	55.1
14	100	70.2
15	83	82.8
16	53	90.8
17	30	95.3
18	15	97.6
19	10	99.1
20	2	99.4
21	2	99.7
22	1	99.8
23	1	100.0

MEAN SCORE = 13.0 NO. OF STUDENTS = 662

STANDARD DEVIATION = 2.7

TABLE 8

FREQUENCY DISTRIBUTION FOR SCORES ON WILLINGNESS TO SURRENDER FREEDOMS

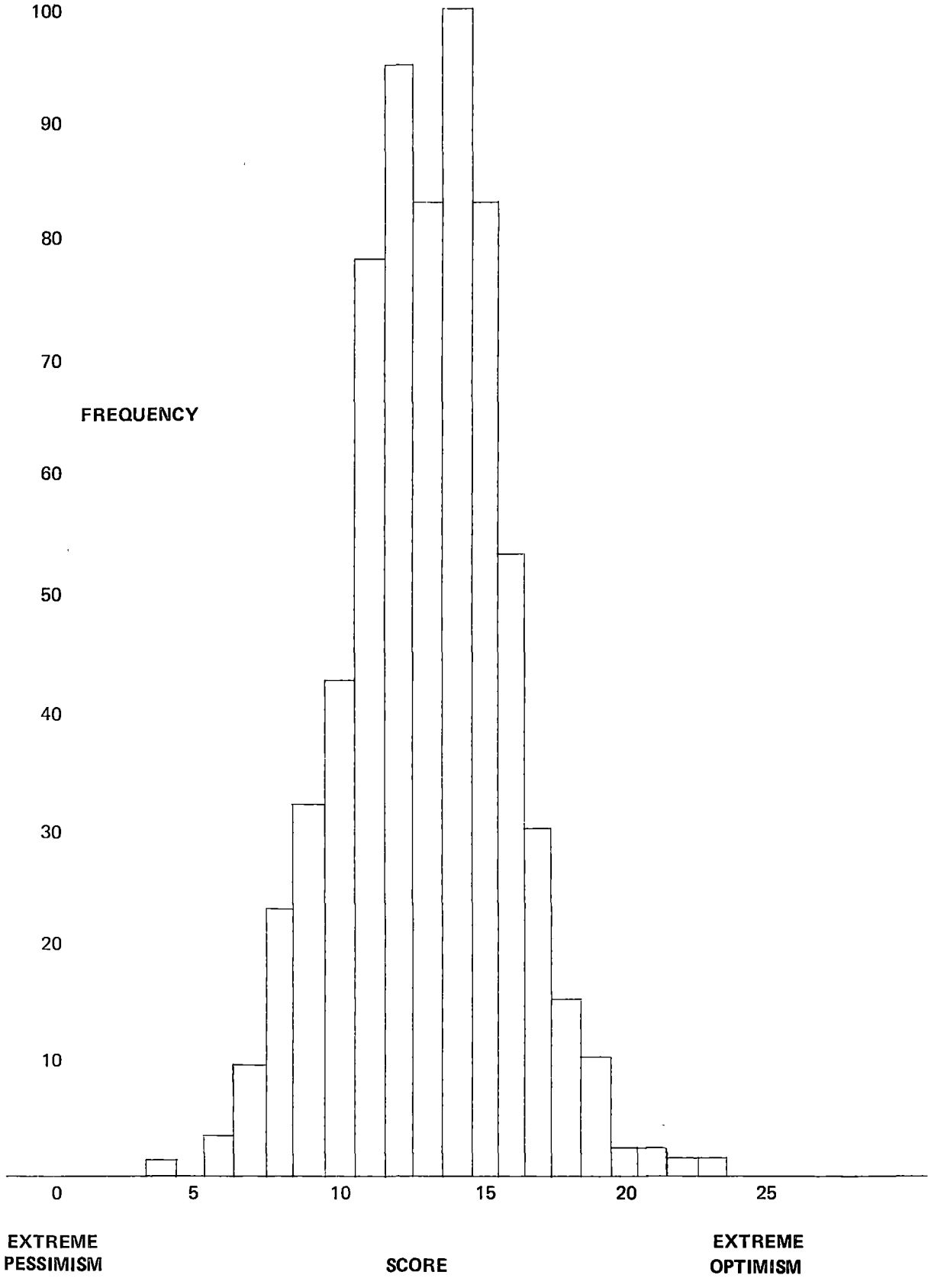
SCORE	FREQUENCY	CUMULATIVE PERCENT
3	1	0.2
8	2	0.5
9	6	1.4
10	6	2.3
11	17	4.8
12	28	9.1
13	39	15.0
14	69	25.4
15	92	39.3
16	101	54.5
17	87	67.7
18	70	78.2
19	51	86.0
20	41	92.1
21	26	96.1
22	13	98.0
23	9	99.4
24	3	99.8
25	1	100.0

MEAN SCORE = 16.3 NO. OF STUDENTS = 662

STANDARD DEVIATION = 2.9

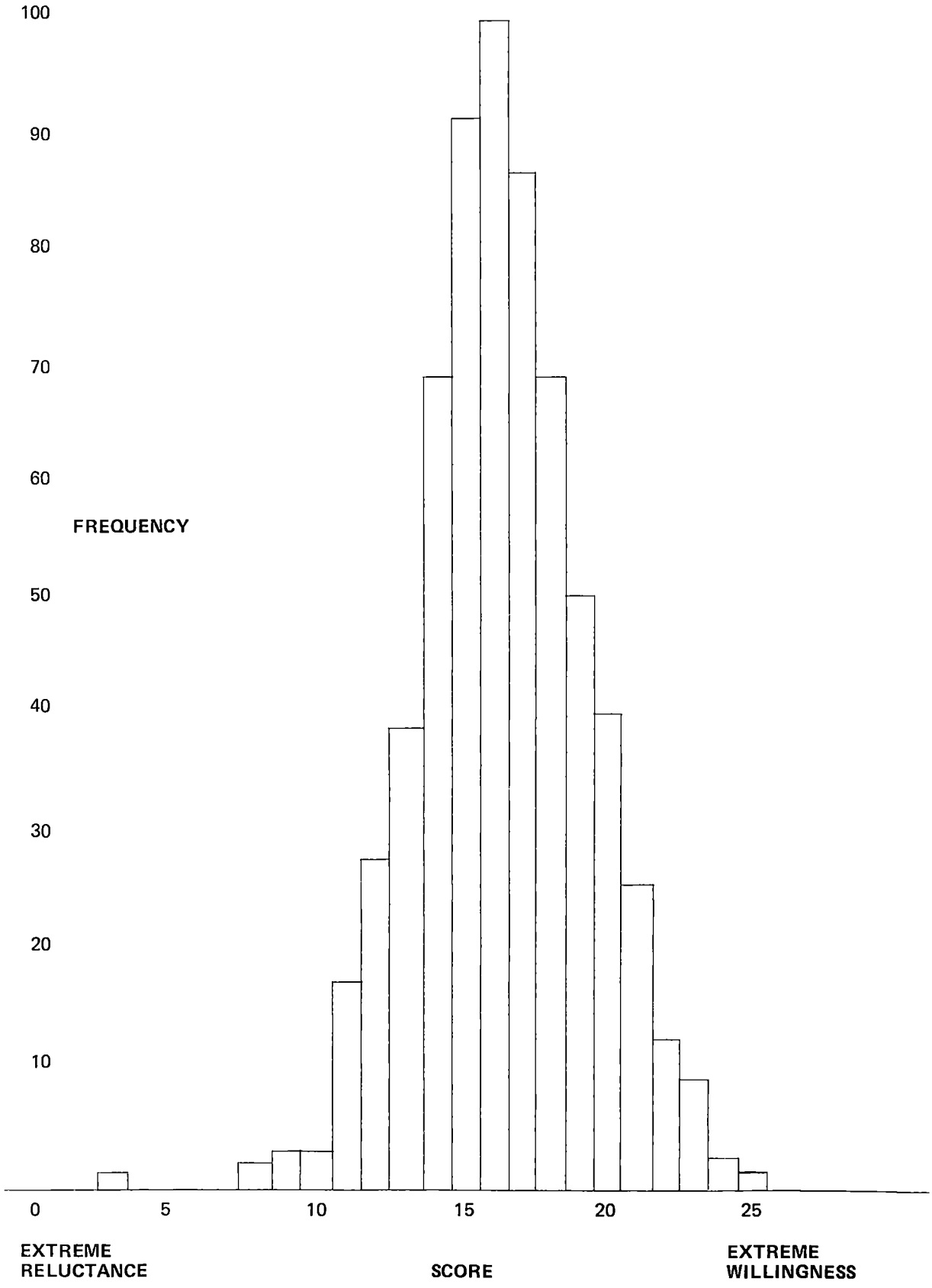
HISTOGRAM OF SCORES

OPTIMISM



HISTOGRAM OF SCORES

WILLINGNESS TO SURRENDER FREEDOMS



6.4 Relationships Between Variables

If it could be shown that knowledge scores were highly correlated with the attitude variables this result would be important, particularly in teaching. Other high inter-correlations would also have implications.

Correlations

From the base correlations used in the SPSS sub-programme REGRESSION[109] the simple inter-variable correlations for which $r \geq 0.100$ have been extracted and are shown in Table 9.

TABLE 9

CORRELATIONS

Knowledge and sex (male = 0, female = 1)	r = -0.181
Knowledge and optimism	r = -0.142
Knowledge and willingness to surrender freedoms	r = 0.215
Knowledge and socio-economic level of school	r = 0.152
Optimism and willingness to surrender freedoms	r = -0.258
Optimism and school, environmental philosophy, (5 schools = 0, School 4 = 1)	r = -0.106
Willingness to surrender freedoms and sex (male = 0, female = 1)	r = 0.156
Willingness to surrender freedoms and school, religious philosophy, (4 schools = 0, Schools 4 and 5 = 1)	r = -0.133

In no case were the inter-correlations very high and the results obtained are discussed in Chapter 7. The correlations are illustrated by cross-tabulations based on the division of the original distributions into upper middle and lower scores for the three major test variables.

Cross Tabulations

The three cross-tabulation operations which were carried out provide a useful representation of the inter-variable correlations. They are shown in Tables 10, 11 and 12.

TABLE 10

CROSS TABULATION OF OPTIMISM TRICHOTOMISED BY KNOWLEDGE TRICHOTOMISED

OPTIMISM	LOWEST	MEDIUM	HIGHEST	
HIGHEST	10.7%	9.8%	9.2%	29.8%
MEDIUM	14.5%	13.7%	13.7%	42.0%
LOWEST	7.3%	8.6%	12.4%	28.2%
	32.5%	32.2%	35.3%	

KNOWLEDGE

Totalling the percentages in the diagonal cells gives 30.2% and 36.8% illustrating the negative correlation (-0.142) obtained from raw scores.

Chi square = 9.47 with 4 degrees of freedom,

level of significance = 0.050

The Chi-square statistic was used to test the hypothesis that the optimism trichotomy was independent of the knowledge trichotomy. This hypothesis of independence was rejected at the 0.05 level of significance. While these variables are not strongly correlated, the result is in line with the expectation that greater knowledge tends to be associated with pessimism.

TABLE 11

CROSS TABULATION OF WILLINGNESS TO SURRENDER FREEDOMS TRICHOTOMISED BY KNOWLEDGE TRICHOTOMISED

WILLINGNESS TO SURRENDER FREEDOMS				
HIGHEST	7.4%	8.9%	16.0%	32.3%
MEDIUM	11.0%	9.5%	7.9%	28.4%
LOWEST	14.0%	13.7%	11.5%	39.3%
	LOWEST	MEDIUM	HIGHEST	
	32.5%	32.2%	35.3%	

KNOWLEDGE

In this case the positive correlation is evidenced by totalling the diagonal cells which gives totals of 39.5% and 28.4% ($r = 0.215$ from raw scores).

Chi square = 29.5 with 4 degrees of freedom, level of significance = 0.000

Use of Chi-square enables rejection of the hypothesis that willingness to surrender freedom and knowledge are independent, the level of significance being less than 0.0005. Here is evidence that greater environmental knowledge tends to be associated with a degree of preparedness to forfeit rights and privileges.

TABLE 12

CROSS TABULATION OF WILLINGNESS TO SURRENDER FREEDOMS

TRICHOTOMISED BY OPTIMISM TRICHOTOMISED

WILLINGNESS TO SURRENDER FREEDOMS					
	HIGHEST	13.0%	13.1%	6.2%	32.3%
	MEDIUM	8.2%	10.7%	9.5%	28.4%
	LOWEST	7.1%	18.1%	14.0%	39.3%
		LOWEST	MEDIUM	HIGHEST	
		28.2%	42.0%	29.8%	

OPTIMISM

The diagonal totals of 24.0% and 37.7% show that the variables willingness to surrender freedoms and optimism are negatively correlated, (raw score value r = -0.258).

Chi square = 34.4 with 4 degrees of freedom,

level of significance = 0.000

Again, the hypothesis that the variables are independent is rejected at a level of significance less than 0.0005.

The largest correlation, between optimism and willingness to surrender freedoms, was expected. There is a tendency for those who are concerned about the future to see the need for personal sacrifices. The inter-correlations also indicate that this group is likely to consist of those with greater environmental knowledge.

Higher mean scores on knowledge for males and willingness to surrender freedoms for females are indicated by the correlations between these variables and sex. The only important relationship involving socio-economic level of the school is its positive correlation with knowledge score.

The negative correlation between optimism and school, (environmental philosophy), reflects the fact that students of School 4 tend to be less optimistic than others. Similarly, the combined scores of Schools 4 and 5 suggest that their students are less prepared to surrender freedoms than those in other schools. (Table 1 lists the schools.)

Multiple Regression

Regression analyses were carried out using each of the three main test variables - knowledge, optimism and willingness to surrender freedoms, as dependent variables with the set of predictor variables. These are sex, optimism, willingness to surrender freedoms, school (single sex or co-educational), school (religious philosophy), school (state or independent), socio-economic level of school and school (environmental philosophy). Tables 13, 14 and 15 list the results of these analyses.

TABLE 13

MULTIPLE REGRESSION USING KNOWLEDGE AS DEPENDENT VARIABLE

Multiple R = 0.396

R^2 = 0.157

Variable	Beta Coefficients for which $\lvert\beta\rvert \geq 0.100$
Sex (male = 0, female =1)	-0.360
School, religious philosophy, (4 schools =0, Schools 4 and 5 =1)	-0.291
School, environmental philosophy, (5 schools =0, School 4 = 1)	0.256
Socio-Economic Level of School	0.193
Willingness to surrender freedoms	0.183
School, single sex or co-educational, (co-educational = 0, single sex =1)	0.113

This technique was described under the heading Correlation Analysis in Chapter 5 (5.4)

The value for R^2 indicates that 15.7% of the variance was explained by the predictor set of eight variables.

This analysis suggests that maleness, absence of a school religious philosophy and possession of a school environmental philosophy are the best predictors of high knowledge scores.

The loading on school, religious philosophy, reflects the low score of School 5, while the loading for school, environmental philosophy, extracts all variance due to School 4.

TABLE 14

MULTIPLE REGRESSION USING OPTIMISM AS DEPENDENT VARIABLE

Multiple $R = 0.190$

$R^2 = 0.036$

Variable	Beta Coefficients for which $\lvert\beta\rvert \geq 0.100$
School, environmental philosophy, (5 schools = 0, School 4 = 1)	-0.271
School, religious philosophy (4 schools = 0, Schools 4 and 5 = 1)	0.247

The value for R^2 shows how little of the variance in optimism scores (3.6%) is attributable to the predictor set of variables.

The strong influence of School 5 scores is seen in the fact that the two beta weights listed are opposite in sign.

TABLE 15

MULTIPLE REGRESSION USING WILLINGNESS TO SURRENDER FREEDOMS AS DEPENDENT VARIABLE

Multiple R = 0.343

R^2 = 0.118

Variable	Beta Coefficients for which $\lvert\beta\rvert \geq 0.100$
School, environmental philosophy, (5 schools = 0, School 4 = 1)	0.562
School, religious philosophy, (4 schools = 0, Schools 4 and 5 = 1)	-0.556
School, single sex or co-educational, (co-educational = 0, single sex = 1)	0.348

In this case the results suggest that 11.8% of the variance is caused by the predictor variables. Again the conflicting effects of scores from School 4 and School 5 are responsible for sign reversals in the first two beta weights.

The results recorded in Tables 13, 14 and 15 show that variables other than those investigated are responsible for most of the variance in scores for knowledge, optimism and willingness to surrender freedoms.

Analysis of Scores by Schools and Other Groups

The school means in rank order and overall mean scores are shown in Table 16. The pessimism score is defined as the negative of the result for optimism. Its use assists in making comparisons with the other variables.

Analysis of variance was the main tool used. Tables 17, 18 and 19 summarise the results obtained from the use of the SPSS programme ONEWAY[110] 39 times.

TABLE 16

RANK ORDERS OF SCHOOLS USING MEAN SCORES

Knowledge (0 to 30)		Pessimism (-25 to 0)		Willingness to Surrender Freedoms (0 to 25)	
School 3	20.4	School 4	-12.3	School 0	17.7
School 4	20.2	School 0	-12.6	School 4	17.0
School 0	19.9	School 3	-13.0	School 1	16.5
School 5	19.2	School 2	-13.2	School 3	16.0
School 1	18.7	School 1	-13.3	School 2	15.7
School 2	17.5	School 5	-13.9	School 5	14.7
Overall	19.4	Overall	-13.0	Overall	16.3

TABLE 17

SUMMARY OF SIGNIFICANCE LEVELS FROM ANOVA OF KNOWLEDGE SCORES AND MEAN SCORES FOR GROUPS

* $P \leq 0.05$ Overall Mean 19.4

Variable	Degrees of Freedom	F Ratio	Level of Significance	Means
Sex	1;660	22.4	0.000*	Male 20.2 Female 18.6
School	5;656	7.0	0.000*	see Table 16
School, Single Sex or Co-educational	1;660	1.1	0.303	Single Sex 19.6 Co-educational 19.2
School, Religious Philosophy or Other	1;660	1.8	0.176	Religious Philosophy 19.7 Other 19.2
School, State or Independent	1;660	6.2	0.013*	State 18.9 Independent 19.8
Socio-Economic Level of School	2;659	14.8	0.000*	Low 18.7 Middle 17.5 Upper 19.9
School, Environmental Philosophy or Other	1;660	4.6	0.032*	Environmental Philosophy 20.2 Other 19.2
School, Non-Catholic Independent or Other	1;660	8.3	0.004*	Non-Catholic Independent 20.0 Other 19.0
Girls, Non-Catholic Independent School or Other	1;338	32.0	0.000*	Non-Catholic Independent 19.7 Other 17.1
Boys, School 4 or Other	1;320	5.3	0.022*	School 4 21.7 Other 20.0
Girls, School 4 or Other	1;338	2.9	0.092	School 4 19.5 Other 18.4
Girls, School 0 or Other	1;338	18.6	0.000*	School 0 19.9 Other 17.8
Students, School 0 or Other	1;660	2.4	0.124	School 0 19.9 Other 19.2

TABLE 18

SUMMARY OF SIGNIFICANCE LEVELS FROM ANOVA OF OPTIMISM SCORES AND MEAN SCORES FOR GROUPS

* $P \leq 0.05$ Overall Mean 13.0

Variable	Degrees of Freedom	F Ratio	Level of Significance	Means
1. Sex	1;660	6.5	0.011 *	Male 13.3 Female 12.8
2. School	5;656	4.9	0.000 *	See Table 16
3. School, Single Sex or Co-educational	1;660	1.1	0.288	Single Sex 13.2 Co-educational 13.0
4. School, Religious Philosophy or Other	1;660	1.1	0.286	Religious Philosophy 13. Other 13.
5. School, State or Independent	1;660	0.7	0.391	State 13.1 Independent 13.0
6. Socio-Economic Level of School	2;659	0.7	0.521	Low 13.3 Middle 13.2 Upper 13.0
7. School, Environmental Philosophy or Other	1;660	7.5	0.006 *	Environmental Philosophy 12.3 Other 13.2
8. School, Non-Catholic Independent or Other	1;660	16.0	0.000 *	Non-Catholic Independent1 Other 13
9. Girls, Non-Catholic Independent School or Other	1;338	7.5	0.006 *	Non-Catholic Independent1 Other 13
10. Boys, School 4 or Other	1;320	3.1	0.081	School 4 12.5 Other 13.4
11. Girls, School 4 or Other	1;338	3.3	0.071	School 4 12.2 Other 12.9
12. Girls, School 0 or Other	1;338	1.9	0.174	School 0 12.5 Other 12.9
13. Students, School 0 or Other	1;660	5.4	0.020 *	School 0 12.5 Other 13.2

TABLE 19

SUMMARY OF SIGNIFICANCE LEVELS FROM ANOVA OF WILLINGNESS TO SURRENDER FREEDOMS AND MEAN SCORES FOR GROUPS

* P $\geq$ 0.05 Overall Mean 16.3

Variable	Degrees of Freedom	F Ratio	Level of Significance	Means
1. Sex	1;660	16.5	0.000 *	Male 15.8 Female 16.7
2. School	5;656	17.6	0.000 *	see Table 16
3. School, Single Sex or Co-educational	1;660	0.0	0.941	Single Sex 16.3 Co-educational 16.3
4. School, Religious Philosophy or Other	1;660	11.9	0.000 *	Religious Philosophy 15.7 Other 16.6
5. School, State or Independent	1;660	3.3	0.069	State 16.1 Independent 16.5
6. Socio-Economic Level of School	2;659	2.5	0.085	Low 16.5 Middle 15.7 Upper 16.4
7. School, Environmental Philosophy or Other	1;660	6.4	0.012 *	Environmental Philosophy 17.0 Other 16.2
8. School, Non-Catholic Independent or Other	1;660	54.8	0.000 *	Non-Catholic Independent 17.4 Other 15.7
9. Girls, Non-Catholic Independent or Other	1;338	47.9	0.000 *	Non-Catholic Independent 17.6 Other 15.7
10. Boys, School 4 or Other	1;320	1.7	0.191	School 4 16.5 Other 15.8
11. Girls, School 4 or Other	1;338	2.9	0.090	School 4 17.3 Other 16.6
12. Girls, School 0 or Other	1;338	30.5	0.000 *	School 0 17.7 Other 16.1
13. Students, School 0 or Other	1;660	41.7	0.000 *	School 0 17.7 Other 15.9

Tables 17, 18 and 19 show there are significant differences between the sexes on each of the variables knowledge, optimism and willingness to surrender freedoms. There are also significant differences between schools on these variables.

The Scheffe[111] procedure yields subsets of groups whose highest and lowest means do not differ by more than the shortest significant range for a subset of that size. Although this analysis yielded little of interest, the results obtained are shown in Table 20; mean scores are in the brackets:

TABLE 20

SCHEFFE SUB SETS

KNOWLEDGE

Schools

Subset 1: School 2 (17.5) School 1 (18.7)
School 5 (19.2)

Subset 2: School 1 (18.7) School 5 (19.2)
School 0 (19.9) School 4 (20.2)
School 3 (20.4)

Socio-Economic Level of Schools

Subset 1: Middle (17.5), Lower (18.7)

Subset 2: Upper (19.9)

OPTIMISM

Schools

Subset 1: School 4 (12.3) School 0 (12.5)
School 3 (13.0) School 2 (13.2)
School 1 (13.3)

Subset 2: School 3 (13.0) School 2 (13.2)
School 1 (13.3) School 5 (13.9)

Socio-Economic Level of Schools

Upper (13.0), Middle (13.2) and Lower (13.3)
comprise a homogeneous set.

TABLE 20 (CONTINUED)

WILLINGNESS TO SURRENDER FREEDOMS

Schools

Subset 1:	School 5 (14.7)	School 2 (15.7)
Subset 2:	School 2 (15.7)	School 3 (16.0)
	School 1 (16.5)	School 4 (17.0)
Subset 3:	School 4 (17.0)	School 0 (17.7)

Socio-Economic Level of Schools

Middle (15.7), Upper (16.4) and Lower (16.5) comprise a homogeneous set.

While differences in knowledge scores between groups based on socio-economic level of school were highly significant, the mean for the lower level was intermediate to those for the higher and middle levels. There was no significant difference between groups based on socio-economic level for either optimism or willingness to surrender freedoms. The knowledge score for a school was also significantly related to whether it was state or independent while, for willingness to surrender freedoms, significantly different results were obtained between schools with an overt religious philosophy (School 4 and 5) and others.

School 4 was the only school deemed to possess an overt environmental philosophy so that, for the variable school (environmental philosophy), its results were compared with those for all other schools. The differences were significant for each variable - knowledge, optimism and willingness to surrender freedoms.

Table 16 showed that School 0 results were very similar to those for School 4. It was decided to conduct further analyses (Listed 8-13 in Tables 16, 17 and 18) to gain additional information about these schools. For them (Non-Catholic Independent Schools) the student scores on each variable were significantly different from the rest of the samples. Similarly, scores for their girls were significantly different from those of other girls. Results of School 4 boys were only significantly different from those of other boys on knowledge. No significant differences were found for School 4 girls from other girls. School 0 students obtained scores significantly different from other girls' on two variables, but not on optimism, though they were significantly different from other students (boys and girls) on this variable as well as willingness to surrender freedoms.

The value of these detailed investigations is questionable because of the coarseness of the sampling. However, because all Grade Eleven students from School 0 were tested, their superiority over other girls in knowledge is noteworthy.

Descriptions have been given of how responses to the test items were analysed and of the wide range of statistical treatments which was used with the results. It is necessary to associate the finding from this work with the information provided in earlier chapters and to draw conclusions. This is done in Chapter 7.

CHAPTER 7

DISCUSSION, COMPARISONS, SUMMARY AND CONCLUSIONS

7. DISCUSSION, COMPARISONS, SUMMARY AND CONCLUSIONS

In the foregoing chapters questions have been asked about environmental education in Brisbane, and credit has been given for some of the changes occurring since the early seventies. A considerable amount of data has been accumulated by testing in schools, and opinions have been expressed which relate to these findings. In Chapter 5 hypotheses were stated. These are now examined in the light of evidence from the use of the test. Table 21 lists the decisions made in respect of the hypotheses, decisions being made at the 0.05 level of significance.

TABLE 21

DECISIONS RELATING TO HYPOTHESES

Hypothesis		Decision
1.	There is no significant relationship between the environmental knowledge of Brisbane Grade Eleven students and	
(a)	sex	rejected
(b)	school	rejected
(c)	type of school (co-educational or single sex)	not rejected
(d)	type of school (with or without an overt religious philosophy)	not rejected
(e)	type of school (state or independent)	rejected
(f)	socio-economic level of school	rejected
(g)	type of school (with or without a stated environmental philosophy)	rejected

TABLE 21 (CONTINUED)

Hypothesis		Decision
2.	There is no significant relationship between the expressed optimism-pessimism attitude to the future of Brisbane Grade Eleven students and	
	(a) environmental knowledge	rejected
	(b) sex	rejected
	(c) school	rejected
	(d) type of school (co-educational or single sex)	not rejected
	(e) type of school (with or without an overt religious philosophy)	not rejected
	(f) type of school (state or independent)	not rejected
	(g) socio-economic level of school	not rejected
	(h) type of school (with or without a stated environmental philosophy)	rejected

Hypothesis		Decision
3.	There is no significant relationship between the expressed attitude to individual freedom of Brisbane Grade Eleven students and	
	(a) expressed optimism-pessimism attitude to the future	rejected
	(b) environmental knowledge	rejected
	(c) sex	rejected
	(d) school	rejected
	(e) type of school (co-educational or single sex)	not rejected
	(f) type of school (with or without an overt religious philosophy)	rejected
	(g) type of school (state or independent)	not rejected
	(h) socio-economic level of school	not rejected
	(i) type of school (with or without a stated environmental philosophy)	rejected

7.1 Discussion of Hypotheses and Questions

The differences between the sexes are of particular interest, the mean knowledge score for males being 20.2, for females 18.6, from a possible score of 30. There are strong moves in education to provide equal opportunities for girls and boys. This could be a factor in reducing the differences. As previously stated Perkes[112] suggests different science backgrounds as a reason for such differences while Eyers[113] proposes that they arise from the lower motivation of girls which is brought about by how they perceive their role in society. A comparison of their work with this study is provided in the next section. In optimism males score higher, 13.3, compared with 12.8 for females. This may reflect a lower level of sensitivity in males or a relative sense of powerlessness in females. Considered with the knowledge difference it is of particular interest as knowledge and optimism are negatively correlated ($r = -0.142$). Males scored lower on willingness to surrender freedoms, 15.8, compared with 16.7 for females. The picture this conjures up is of compliant females contrasting with aggressive (possibly selfish) males who cherish their opportunities for self-determination. This is another interesting result when considered with the knowledge scores as knowledge and willingness to surrender freedoms are positively correlated ($r = 0.215$).

Each hypothesis relating a major variable (knowledge, optimism and willingness to surrender freedoms) to school was rejected. While this may be regarded as illustrative of commendable diversity in schools it may also be viewed as a pointer to regrettable deficiencies in some schools. The knowledge scores for schools ranged from 17.5 to 20.4.

Whether schools were co-educational or single sex bore no significant relationship to any of the major variables and it was only for the variable knowledge that there was a significant relationship with school, (state or independent), and socio-economic level of school. Independent schools scored higher than state schools on knowledge (19.8 compared with 18.9) but the results for different socio-economic levels of school were inconclusive though significantly different. The order is anomalous. (Low 18.7, Middle 17.5, Upper 19.9).

The rejection of the three hypotheses concerned with type of school (with or without a stated environmental philosophy) is noteworthy, even though only one school was involved. Students from this school had significantly higher knowledge scores, significantly lower optimism and significantly greater willingness to surrender freedoms.

The results suggest that a school's possession of an overt religious philosophy is not related to knowledge scores or optimism-pessimism but that it is related to willingness to surrender freedoms. Two schools contributed to these results, Schools 4 and 5. For the attitude scores they were at opposite ends of the rankings (Table 16) and the significant differences for the attitude variables were caused by the overwhelming dominance of School 5. There is insufficient evidence of any meaningful association of school religious philosophies and scores on willingness to surrender freedoms.

It remains to consider the hypotheses involving knowledge and the two attitudes. Tables 10, 11 and 12 illustrate the relationships. These results confirmed expectations. Students with greater knowledge as measured by the test were shown to be significantly less optimistic than others and more prepared to surrender freedoms. Students with high environmental knowledge scores could be expected to have a greater realisation of the threats to the world and to mankind's continued existence. In the interests of survival they would be likely to accept a necessity to forfeit some of their rights and privileges. The inverse relationship between optimism and willingness to surrender freedoms is also predictable.

A re-examination of the questions asked in Chapter 1 shows that some have been answered, at least in part. Replication of the investigation with larger samples would very likely confirm the indication that a school environmental philosophy is associated with greater environmental knowledge and more enlightened attitudes for its students. Certainly strong knowledge - attitude and knowledge - sex relationships have been demonstrated. The questions concerning religious philosophy, socio-economic level and the differences between state and independent schools require further research.

The test contributes some information as to whether the aims[114] of the Queensland Education Department are being met. A mean knowledge score of 18.9 out of 30 on a wide-ranging test indicates a degree of success in the knowledge areas. This question is also answered in Chapter 2 by the subjective assessment that teachers are engaging in worthwhile environmental education via the stated aims and that the situation is improving.

However, there is no cause for complacency, some serious knowledge deficiencies being revealed in Chapter 6 (6.2).

7.2 Comparisons with Other Research

It is interesting to compare results from this study with the findings of Perkes[115], Eyers[116], and Richmond[117]. In each case males were shown to have significantly greater environmental knowledge than females. A similar unanimity was not found in the case of belief scores. This investigation found males to be significantly more optimistic and significantly less willing to surrender freedoms than females. Eyers also found that males were less prepared to surrender their rights. His differences between the sexes on belief items were significant while Richmond in England and Perkes in U.S.A. found only slight differences.

In the other Australian study Eyers found little difference in knowledge scores for different types of schools (State, Catholic, Independent). This study found significant differences between schools and here there is great potential interest and importance. Other investigations are needed to explore between school differences.

Another comparison can be made with Richmond's work in England. He obtained correlations of 0.38 and 0.48 between knowledge scores and attitude scores. These figures are much higher than the inter-correlations obtained in Brisbane. For knowledge and willingness to surrender freedoms it was 0.21. In Richmond's work a high attitude score means agreement with the answer accepted by a panel of experts. Good students would tend to score well on attitudes and knowledge, poor students would tend to get low scores. In the Brisbane study this would be less likely to apply as there was no single

correct answer for the attitude questions. Perhaps this explains the lower correlations.

Stated attitudes may differ greatly from related behaviours as numerous studies have shown, for example those of La Piere[118] and Figa-Talamanca[119]. In this investigation 94% of students agreed or strongly agreed that there should be stronger laws to control littering and conservation and that they should be rigidly enforced. This implies identification with those who oppose littering. Yet, in the preliminary testing, 90% of a similar student sample admitted to littering within the last month. The more difficult task of investigating and comparing student behaviours in relation to environmental knowledge has still to be undertaken.

7.3 Summary and Conclusions

The aim of this research was to investigate environmental education in Brisbane, particularly at the Grade Eleven level. In the first chapter the specific aims were listed - the construction of a test of environmental knowledge and attitudes, a Brisbane survey, use of the test to investigate knowledge and attitudes and comparison with other research. These aims have been achieved, some more successfully than others.

In Chapter 1 a case is made for environmental education as a field of increasing importance and the need is established for a study of this kind. Chapter 2 describes the opportunities for environmental education in Brisbane and includes favourable comment on its current status. Chapter 3 reviews the research of others in this field. The steps taken to design the test from first principles are outlined in Chapter 4 and the way it was used is detailed in Chapter 5.

While the increased attention to environmental education in schools has been commended, certain of the findings made give cause for concern. Among them is the inadequacy of knowledge in some areas which is revealed in the analysis of responses in Chapter 6. Failure to appreciate that the earth's resources are limited, to understand evolutionary processes and the inter-relatedness of living things are among these findings. They are a reminder that some environmental and ecological concepts are difficult for children to grasp and that children vary greatly in their capacities to integrate the knowledge they gain. These findings also suggest that the success of an inter-disciplinary approach to environmental education makes heavy demands on teachers and curriculum planners.

A weakness in the research is that, although schools were asked to provide representative samples of Grade Eleven students, random samples were not taken. Also, only six schools were investigated, as representative of the main types of school in Brisbane. Because of these facts there are definite limitations upon any inferences which may be drawn from the results.

An obvious conclusion is that a larger study is needed. The test could be administered in a number of state and independent schools, in several schools professing environmental philosophies and religious philosophies. The socio-economic level of schools could be used again as a variable. The same attitudes could be investigated and others included to extend the study. Using observed behaviour rather than stated attitudes would strengthen the research considerably. New tests could be constructed using the methodology this study has described in detail. Subjective evaluation is of limited value, yet this is the main way in which environmental education is assessed.

Passineau[120] points to the need for better assessment instruments and evaluation methodologies for environmental education, claiming that there is "a great need for sophisticated and imaginative research and evaluation which attempts to determine the relationships between teaching environments and learning effectiveness."

While the increased provision for environmental education in Brisbane schools is heartening, there is a constant need to monitor it and assess its effectiveness. This study is a first step in that direction.

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APPENDIXES

APPENDIX 1.

NAME OF STUDENT: _____

ENVIRONMENTAL EDUCATION TEST 5

INSTRUCTIONS

Enter your name and number on this page and on two computer cards using the pencil provided.

Under the heading "Answer Card Sequence" on the computer card mark 1 for your first card (items 1-30) and 2 for the second card (items 31-60).

For each item select the best alternative, mark it with a tick and record your choices on the computer cards.

There is only one best answer for each of the items.

* * *

1.

Most electricity in Australia is produced in

A. power-houses which burn gas
B. power-houses which burn oil
C. power-houses which burn coal
D. hydro-electric projects

2.

For photosynthesis to occur in plants it is necessary to have

A. organic material in the soil
B. super-phosphate applied regularly
C. an atmosphere which allows sunlight to pass through
D. the presence of trace elements including boron

3.

Ozone is

A. the gas in most pressure packs
B. a chemical spray which kills insects
C. the outer area of an ecosystem
D. a gas in the upper atmosphere

4.

Because the water in the biosphere is involved in a continuous recycling process, at any one time a particular water molecule is most likely to be in

A. one of the world's oceans
B. the earth's atmosphere
C. the cells of a plant or animal
D. a lake, river or other stream

5.

Which of the following relates most closely to forces between the earth and the moon?

A. the energy available as tidal power
B. cyclones and anti-cyclones
C. the distance to our nearest star
D. folding and faulting of the earth's crust

6.

Depositing organic rubbish in compost heaps

A. provides a habitat for worms
B. enables bacteria to be killed off
C. is the major cause of infectious disease
D. prevents the formation of carbon dioxide

7.

Which of the following makes for good soil?

A. a pH value below 4
B. the presence of nitrogen - fixing bacteria
C. an increased concentration of sodium chloride
D. provision for regular leaching

8.

Which of the following groups of elements is essential in soil for the best plant growth?

A. nitrogen, cadmium, lead
B. magnesium, phosphorus, lead
C. nitrogen, phosphorus, potassium
D. magnesium, cadmium, potassium

9.

A balanced vegetarian diet can be recommended for human beings because it

A. ensures that a maximum of protein is available
B. allows for a short energy-efficient food chain
C. provides more calories than any other diet
D. lacks any carbohydrate or fat content

10.

Within a forested area

A. the earth is shielded from all solar radiation
B. carbon dioxide is converted to oxygen
C. few ecological interactions occur
D. the soil is always strongly acidic

11.

In food chains there are usually small numbers of the top carnivore and large numbers of herbivores with intermediate numbers in between. The plant populations are usually very large. If there is to be enough food for all the world

A. it is more efficient to supply plants for food rather than animals
B. breeding more of the top carnivore species is essential
C. there should be laws to protect the top carnivore species
D. people should be encouraged to eat herbivores

12.

Assume that for each step in a food chain there is an ecological efficiency of ten percent e.g. ten percent of the energy taken in by a predator is retained until it is preyed upon.
In the food chain :

leaf - moth - lizard - kookaburra,

for each Calorie gained by kookaburras how much leaf energy is eaten by moths?

A. 1000 Calories
B. 10 Calories
C. 1/10 Calorie
D. 1/1000 Calorie

13.

400 mullet from a lake were caught, tagged and released again in the lake. A week later 100 mullet caught in the same place included 10 which had been tagged. The best estimate of the lake's total mullet population is

A. 490
B. 500
C. 3000
D. 4000

14.

There is a large increase in the food supply for an animal species at a time when there are few of its predators.

The most likely result of this is

A. no change in the population of the species but a sudden increase in the number of predators
B. the numbers of predators and their prey becoming approximately equal
C. a further decrease in predator numbers
D. an increase in the population of the species followed by an increase in the predator population

15.

Which of the following applies to both the early Australian aborigines and most of today's white population?

A. homes in urban centres
B. hunters and food gatherers
C. fish included in their diet
D. very likely to develop skin cancer

16.

Which of the following is true for Australia?

A. large numbers of people have moved from the country to the cities
B. most of the population consists of migrants from overseas
C. the ten year average population increase is 7 percent per annum
D. there are plans for new cities to be bigger than Brisbane by 1990.

17.

Which is the best description of a typical Australian dwelling?

A. two rooms, privately owned
B. twelve or more rooms, air-conditioned
C. one bedroom, high rise building
D. two or three bedrooms, large allotment

18.

The earth is said to be like a spaceship.
This is because it is

A. travelling through space at the speed of light
B. unable to increase its available amounts of air and water
C. moving in a direction which cannot change
D. equal in weight to the volume of gas it displaces

19.

Energy stored in coal and natural gas

A. is doubled by converting it to heat energy
B. is the most expensive energy obtainable
C. cannot be converted to any quantity of electricity
D. had the sun as its original source

20.

With which one of the following statements do you agree most?

A. Certain harmful chemicals build up in the bodies of birds
B. The sea will always be a suitable place for waste water to run
C. Each year the air is purified because it is recycled
D. There are no problems associated with dumping rubbish to make sports grounds

21.

Which of the following suggestions do you consider could have the most important benefit for the world?

A. The introduction of a cheap plastic which decomposes in soil
B. A twenty percent reduction in expenditure on wrapping in stores
C. Laws requiring all cans to be made of aluminium
D. People retaining more empty packets and containers for storage in the home

22.
Which one of the following claims do you reject?

A. The life in an ecosystem depends on its soil and rocks
B. Changes on the sun affect life on earth
C. Most species found on earth have evolved in the last two thousand years
D. Many types of algae depend upon photosynthesis for growth

23.
With which one of the following do you agree?

A. When electricity is made from coal some energy is lost in heating the environment
B. There is a negligible energy use in constructing hydro-electricity schemes compared with their annual energy production
C. All the energy in plants is retained by animals which eat them
D. Where life exists (in the biosphere) each time energy is transferred the total energy increases

24.
Which of the following aims relating to the world's population is most likely to benefit mankind in the future?

A. All countries should have the same population density
B. Prosperous countries like West Germany and U.S.A. should increase their population
C. There should be no interference in third world countries
D. Zero population growth should be achieved as soon as possible

25.
Which of the following countries suffers least from overpopulation?

A. Mexico
B. Holland
C. France
D. Japan

26.
Which one of the following lacks major developed oil fields?

A. the North Sea
B. Venezuela
C. Iran
D. Central Australia

27.
As a result of many families using two cars

A. there has been a slight decrease in the number of bicycles sold in recent years
B. the number of Australians employed making cars has doubled since 1975.
C. all new houses have double garages or car-ports
D. more oil and steel has to be produced

28.
Which is the most likely long term result of disregarding ecological considerations?

A. environmental losses which are slight compared with the gains of progress
B. little change because nature does not depend on man
C. changes which will make the world an unattractive place
D. some change in animal and plant populations

29.

Which of the following is a favourable result of burning back yard rubbish?

A. the ashes contain potash
B. carbon dioxide is produced
C. solid particles in the air are increased
D. the smoke sterilises the upper atmosphere

30.

Which of the following is true?

A. In most underdeveloped countries the population has remained about the same in recent years
B. The total world population increases greatly each year
C. The United States has the world's greatest rate of population increase
D. Australia's population is expected to double by 1990

31.

Which is the most likely long term result of increased migration and intermarriage between people of different races?

A. The percentage of childless marriages would increase
B. Most people would have darker skin than typical Europeans of today
C. The human race would decline in intelligence and physical strength
D. People with fair hair and black skin would become very common

32.

With which of the following statements do you agree?

A. As the world's supply of metals decreases their prices can be expected to increase
B. Huge deposits of coal are formed each year as plants are covered over
C. Copper and steel are being used increasingly to replace aluminium
D. The mineral resources of the earth are distributed evenly throughout the world

33.

With which of the following statements do you agree?

A. The sun's energy will be used up within a thousand years
B. The activities of people are helping to heat the earth and its atmosphere
C. Plants and trees use up all the carbon dioxide produced by man
D. Ash from volcanoes is never likely to affect the world's temperatures

34.

With which of the following statements do you agree?

A. Farming the sea will provide enough food for the world within five years
B. Problems of diet for people in underdeveloped countries can be solved by providing more carbohydrate food
C. The world's most important food plants are rice, wheat and corn
D. Within five years a cheap process for obtaining fresh water from salt water will solve food production problems in dry areas of the world

35. Which of the following is <u>not</u> a feature of Australian life?

A. Nuclear radiation in the major cities is at present a serious health hazard
B. The air above cities has a different composition from air in the country
C. Noise on some construction sites reaches harmful levels
D. Electric wires and posts interfere with views in the cities and suburbs

36. A necessary step to be taken in Australia is to

A. expand the whaling industry
B. increase the phosphates in our rivers
C. improve methods of waste disposal
D. encourage the use of insecticides

37. The main benefit of an increase in the use of public transport instead of cars would be that people could

A. enjoy greater privacy
B. travel in absolute safety
C. be more independent
D. assist in saving energy

38. Various countries have different proportions of their populations living in cities. Compared with the rest of the world the extent of urbanisation in Australia is

A. very high
B. moderate
C. low
D. very low

39. If huge numbers of a particular species are killed in one year

A. it will be extinct within ten years
B. populations of other species will be affected
C. disease will attack the remaining individuals
D. the next generation will be born with better survival abilities

40. What is the likely effect of several years of good seasons with heavy rainfall in dry parts of Australia?

A. increases in the populations of birds
B. the evolution of many new eucalyptus species
C. an overall decline in marsupial numbers through drownings
D. most fish in inland streams washed out to sea

41. In the food chain
plankton - small fish - large fish - man
the greatest number of individuals is at the level

A. man
B. large fish
C. small fish
D. plankton

42. The sea could contribute much more to world food supplies through

A. the use of photosynthesis by algae
B. prohibiting the removal of plankton
C. discoveries of new fish species
D. processes converting whale oil to useful food

43. Which of the following gases is not likely to cause problems because of its increasing concentration in the air?

A. nitrogen
B. oxides of nitrogen
C. sulphur dioxide
D. carbon dioxide

44. If a radioactive element has a half-life period of 40 days the amount left after 160 days from a 16 gram sample would be

A. 8 grams
B. 4 grams
C. 2 grams
D. 1 gram

45. A disadvantage of recycling is that, though it may save materials, it

A. is illegal
B. annoys union leaders
C. must be done overseas
D. uses extra energy

46. Individual citizens can best help improve their neighbourhoods by

A. working through members of parliament and councils
B. going on strike
C. refusing to use bad roads and unsatisfactory services
D. taking neighbours and the government to court

47. A disadvantage of electric cars is that

A. their batteries often need recharging or replacing
B. passengers are in danger of electrocution
C. they are too fast
D. they need to be made of non-conducting material

48. The decomposition of substances so that elements are recycled is best performed by certain

A. herbivores
B. carnivores
C. bacteria
D. nitrogen-fixing organisms

49. Which of the following has an important function when dissolved in river water and is present in very small amounts in badly polluted streams?

A. carbon monoxide
B. oxygen
C. hydrogen
D. boron

50.
In Queensland the land use which involves the greatest area at this time is

A. national parks
B. grazing
C. farming
D. forestry operations

51.
Which of the following can <u>not</u> be recommended as sound long term farming practice

A. planting different crops in different seasons
B. contour ploughing
C. always having the maximum area under crops
D. ploughing in certain crops

52.
When mangrove swamps are reclaimed

A. a law requires one third of the area to be made a park
B. the land is unsuitable for home construction
C. care is usually taken to preserve the trees
D. important habitats for fish life may be lost

53.
There is a possibility that a person will absorb the harmful element lead by

A. painting with acrylics
B. spraying the contents of aerosol cans
C. using D.D.T. sprays
D. breathing fumes from car exhausts

54.
If present trends continue which of the following is most likely to occur to the Australian population in the next fifty years

A. the total will increase at a constant rate
B. the total will decline at a constant rate
C. the proportion of people under twenty will increase
D. the proportion of people over sixty will increase.

55.
An approximation to the population of Sydney is

A. 20,000
B. 200,000
C. 2,000,000
D. 20,000,000

56.
The countries with the greatest populationgrowth rate are

A. very prosperous
B. mainly dependent on secondary industry
C. very dependent on both primary and secondary industry
D. underdeveloped

57.
An approximation to the population of Australia is

A. 14 million
B. 140 million
C. 1,400 million
D. 14,000 million

58.

An advantage provided by a hot water system which depends completely on solar power is

A. guaranteed hot water in all weather conditions
B. low installation cost
C. low running cost
D. hotter water than electric systems produce

59.

In Australia, and based on present discoveries and rates of use, which one of the following fuels can be expected to last the longest?

A. heavy oil
B. light oil
C. natural gas
D. coal

60.

It is likely that the waste from a nuclear power station

A. can be safely stored indefinitely in steel tanks
B. is used in industry as a source of energy
C. will contribute to radioactive pollution
D. can do no harm after 50 years.

* * *

APPENDIX 2 - FINAL TEST.

NAME OF STUDENT: NUMBER:

SEX :

SCHOOL :

ENVIRONMENTAL EDUCATION TEST

INSTRUCTIONS

Fill in the details required on this page and enter your number and name on each of the two computer cards using the pencil provided.

Your number should be indicated to the computer by vertical marks between the brackets in the appropriate rectangles in the first three columns on the left side of the cards. In the fourth column put a vertical mark between the brackets in the zero rectangle if you are male and between the brackets in the "1" rectangle if you are female.

Under the heading "Answer Card Sequence" on the computer card put a vertical mark in the bracket containing "1" for your first card (items 1-30) and a mark in the bracket containing "2" for your second card (items 31-40).

For each of the items select the best alternative, mark it on the question paper for your information when the papers are returned, and also record your choices by vertical marks on the computer cards between the brackets in the appropriate rectangles.

Choose only one answer for each question but be sure that each question is answered.

1.
Most electricity in Australia is produced in

A. power-houses which burn gas
B. power-houses which burn oil
C. power-houses which burn coal
D. hydro-electric projects

2.
For photosynthesis to occur in plants it is necessary to have

A. organic material in the soil
B. super-phosphate applied regularly
C. an atmosphere which allows sunlight to pass through
D. the presence of trace elements including boron

3.
Ozone is

A. the gas in most pressure packs
B. a chemical spray which kills insects
C. the outer area of an ecosystem
D. a gas in the upper atmosphere

4.
Which of the following makes for good soil?

A. a pH value below 4
B. the presence of nitrogen - fixing bacteria
C. an increased concentration of sodium chloride
D. provision for regular leaching

5.
A balanced vegetarian diet can be recommended for human beings because it

A. ensures that a maximum of protein is available
B. allows for a short energy-efficient food chain
C. provides more Calories than any other diet
D. lacks any carbohydrate or fat content

6.
Within a forested area

A. the earth is shielded from all solar radiation
B. carbon dioxide is converted to oxygen
C. few ecological interactions occur
D. the soil is always strongly acidic

7.
If there is a large increase in the food supply for an animal species at a time when there are few of its predators the most likely result of this is

A. no change in the population of the species but a sudden increase in the number of predators
B. the numbers of predators and their prey becoming approximately equal
C. a further decrease in predator numbers
D. an increase in the population of the species followed by an increase in the predator population

8.
Which of the following is true for Australia?

A. large numbers of people have moved from the country to the cities
B. most of the population consists of migrants from overseas
C. the ten year average population increase is 7 percent per annum
D. there are plans for new cities to be bigger than Brisbane by 1990.

9.
Which is the best description of a typical Australian dwelling?

A. two rooms, privately owned
B. twelve or more rooms, air-conditioned
C. one bedroom, high rise building
D. two or three bedrooms, large allotment

10.
The earth is said to be like a spaceship.
This is because it is

A. travelling through space at the speed of light
B. unable to increase its available amounts of air and water
C. moving in a direction which cannot change
D. equal in weight to the volume of gas it displaces

11.
With which one of the following do you agree?

A. When electricity is made from coal some energy is lost in heating the environment
B. There is a negligible energy use in constructing hydro-electricity schemes compared with their annual energy production
C. All the energy in plants is retained by animals which eat them
D. Where life exists (in the biosphere) each time energy is transferred the total energy increases

12. Which of the following countries suffers least from overpopulation?

A. Mexico
B. Holland
C. France
D. Japan

13.
Which one of the following lacks major developed oil fields?

A. the North Sea
B. Venezuela
C. Iran
D. Central Australia

14.
As a result of many families using two cars

A. there has been a slight decrease in the number of bicycles sold in recent years
B. the number of Australians employed making cars has doubled since 1975
C. all new houses have double garages or car-ports
D. more oil and steel has to be produced

15. Which of the following is true?

A. In most underdeveloped countries the population has remained about the same in recent years
B. The total world population increases greatly each year
C. The United States has the world's greatest rate of population increase
D. Australia's population is expected to double by 1990

16. Which is the most likely long term result of increased migration and intermarriage between people of different races?

A. The percentage of childless marriages would increase
B. Most people would have darker skin than typical Europeans of today
C. The human race would decline in intelligence and physical strength
D. People with fair hair and black skin would become very common

17. With which of the following statements do you agree?

A. The sun's energy will be used up within a thousand years
B. The activities of people are helping to heat the earth and its atmosphere
C. Plants and trees use up all the carbon dioxide produced by man
D. Ash from volcanoes is never likely to affect the world's temperatures

18. With which of the following statements do you agree?

A. Farming the sea will provide enough food for the world within five years
B. Problems of diet for people in underdeveloped countries can be solved by providing more carbohydrate food
C. The world's most important food plants are rice, wheat and corn
D. Within five years a cheap process for obtaining fresh water from salt water will solve food production problems in dry areas of the world

19. A necessary step to be taken in Australia is to

A. expand the whaling industry
B. increase the phosphates in our rivers
C. improve methods of waste disposal
D. encourage the use of insecticides

20. If huge numbers of a particular species are killed in one year

A. it will be extinct within ten years
B. populations of other species will be affected
C. disease will attack the remaining individuals
D. the next generation will be born with better survival abilities

21. What is the likely effect of several years of good seasons with heavy rainfall in dry parts of Australia?

A. increases in the populations of birds
B. the evolution of many new eucalyptus species
C. an overall decline in marsupial numbers through drownings
D. most fish in inland streams washed out to sea

22. If a radioactive element has a half-life period of 40 days the amount left after 160 days from a 16 gram sample would be

A. 8 grams
B. 4 grams
C. 2 grams
D. 1 gram

23. A disadvantage of electric cars is that

A. their batteries often need recharging or replacing
B. passengers are in danger of electrocution
C. they are too fast
D. they need to be made of non-conducting material

24. The decomposition of substances so that elements are recycled is best performed by certain

A. herbivores
B. carnivores
C. bacteria
D. nitrogen-fixing organisms

25. Which of the following has an important function when dissolved in river water and is present in very small amounts in badly polluted streams?

A. carbon monoxide
B. oxygen
C. hydrogen
D. boron

26. In Queensland the land use which involves the greatest area at this time is

A. national parks
B. grazing
C. farming
D. forestry operations

27. An approximation to the population of Sydney is

A. 20,000
B. 200,000
C. 2,000,000
D. 20,000,000

28.
An approximation to the population of Australia is

A. 14 million
B. 140 million
C. 1,400 million
D. 14,000 million

29.
An advantage provided by a hot water system which depends completely on solar power is

A. guaranteed hot water in all weather conditions
B. low installation cost
C. low running cost
D. hotter water than electric systems produce

30.
It is likely that the waste from nuclear power stations

A. can be safely stored indefinitely in steel tanks
B. is used in industry as a source of energy
C. will contribute to radioactive pollution
D. can do no harm after 50 years

Please continue to the next page.

The remaining ten questions are concerned with beliefs and attitudes and there are no "correct" answers. For each statement select the alternative which indicates your opinion.

31.
Mankind will become extinct within a few hundred years.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

32.
Citizens should be prepared to pay more for goods so that firms are able to pay for pollution control.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

33.
As each year passes Australia becomes a better place to live in.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

34.
People should always have the right to decide the number of children they have.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

35.
Radioactive waste and other pollution will eventually make the world uninhabitable.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

36.
There should be stronger laws to control littering and conservation and they should be rigidly enforced.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

...7.

37.
By the year 2050 world problems such as war and poverty will be solved.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

38.
In future years it may be necessary for individuals to give up some of their freedom for the general welfare of mankind.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

39.
In Australia the conservation measures which are being taken by governments are adequate.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

40.
In Australia people should be able to use cars as much as they wish even if they cause over-crowding on the roads and serious pollution.

A. strongly agree
B. agree
C. uncertain
D. disagree
E. strongly disagree

* * *